BLUEPRINT READING AND SKETCHING

NAVY TRAINING COURSES

NAVPERS 10077-A

BLUEPRINT READING
and
SKETCHING

Prepared by

BUREAU OF NAVAL PERSONNEL

NAVY TRAINING COURSES

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THE UNITED STATES NAVY

GUARDIAN OF OUR COUNTRY

The United States Navy is responsible for maintaining control of the sea and is a ready force on watch at home and overseas, capable of strong action to preserve the peace or of instant offensive action to win in war.

It is upon the maintenance of this control that our country's glorious future depends; the United States Navy exists to make it so.

WE SERVE WITH HONOR

Tradition, valor, and victory are the Navy's heritage from the past. To these may be added dedication, discipline, and vigilance as the watchwords of the present and the future.

At home or on distant stations we serve with pride, confident in the respect of our country, our shipmates, and our families.

Our responsibilities sober us; our adversities strengthen us.

Service to God and Country is our special privilege. We serve with honor.

THE FUTURE OF THE NAVY

The Navy will always employ new weapons, new techniques, and greater power to protect and defend the United States on the sea, under the sea, and in the air.

Now and in the future, control of the sea gives the United States her greatest advantage for the maintenance of peace and for victory in war.

Mobility, surprise, dispersal, and offensive power are the keynotes of the new Navy. The roots of the Navy lie in a strong belief in the future, in continued dedication to our tasks, and in reflection on our heritage from the past.

Never have our opportunities and our responsibilities been greater.

PREFACE

Blueprint Reading and Sketching is written as a basic reference book for the enlisted men of the Navy whose duties require a knowledge of blueprint reading and sketching. The book contains information necessary for performing the duties of both aviation and other general service ratings requiring this knowledge.

Beginning with a general discussion of the uses and kinds of blueprints, the text explains the language of a blueprint—lines, sections, symbols, dimensions, conventions, notes, and titles. Technical sketching is described and illustrated. Ways are suggested by means of which anyone can produce correct and attractive sketches.

The sections on wiring and schematic diagrams are fairly extensive in accordance with the increased training demands in electrical and electronic equipment and in order to acquaint operating personnel more rapidly with the symbolic notation now being standardized throughout the armed services.

Sections on welding, structural, and architectural symbols are included to help the ratings concerned with these subjects and to introduce them to standards now established in these fields. An index, a list of useful references, and a list of abbreviations are included as aids to the trainee using this book.

While studying this book, a man should refer frequently to typical blueprints of Navy installations and equipment. Such prints are available in technical manuals published by both the Navy and the manufacturers of Navy equipment.

This book is one of the basic NAVY TRAINING COURSES and represents the joint endeavor of the Naval Air Technical Training Command and the Training Publications Section of the Bureau of Naval Personnel.

READING LIST

1. *A Manual of Engineering Drawing for Students and Draftsmen*, T. E. French, McGraw-Hill, New York, N. Y., 694 pages. This text should answer nearly all questions regarding blueprints, from layout to maps; but it contains only a page or two on electrical drawings. It may be obtained in almost any library or commercial bookstore.
2. JAN Standards or MIL Standards. These are standards established to insure uniform practice by the Army, Navy, and Air Force; known as JAN, or Joint Army-Navy Standards, or MIL, Military Standards.

Copies of these standards should be available on all ships and stations having any sizable construction or repair facilities. Commanding officers and officers-in-charge may request copies from their district publications and printing office. Only a few standards are listed here.

Note. Not only do symbols and usages change from time to time, but new ones are introduced. Accordingly, it would be well to check publication dates when using these standards to insure that you have the latest.

Short title	*Latest edition*	*Long title and contents*
JAN–STD–1	13 May 1948	*National Military Establishment Standards for General Drawing Practice.* Topics: Projection, Line Conventions, Section and Sectioning Conventions, Scale, Lettering.
MIL–STD–8A	5 June 1953	(Superseding MIL–STD–8 30 December 1949) *Military Standard Dimensioning and Tolerancing.* Dimensioning Topics: Types of, Specifying Size, Rules for, etc. Tolerancing Topics: Methods of, Practice of, Positional Tolerancing, etc.
MIL–STD–10	2 Aug 1949	*Military Standard, Surface Roughness, Waviness, and Lay.* Topics: Definitions, Surface Roughness Number, Waviness and Lay, Surface Symbols.

Short title	*Latest edition*	*Long title and contents*
MIL-STD-12A	11 Mar 1952	(Superseding JAN-STD-12, 13 March 1947.) *Military Standard Abbreviations for Use on Drawings*. Abbreviations, Metals and Chemicals (Symbols), Cable and Magnet Wire (Abbreviations and Symbols), Engineering Societies, Trade Associations, Inspection Bureaus, Army and Navy Rank, and Government Organizations.
MIL-STD-15A	1 Apr 1954	(Superseding JAN-15, 19 October 1948.) *Military Standard Electrical and Electronic Symbols*. Topics: Introduction and General Requirements, Drafting Practices, General List of Symbols, Symbols for Marine Equipment, Symbols for Electrical Equipment in Buildings and Building Distribution Systems.
MIL-STD-16A	18 Apr 1952	(Superseding MIL-STD-16, 16 February 1951) *Military Standard Electrical and Electronic Reference Designations*. Topics: Definitions, Formation, Application, Special Procedures for Sockets and Connectors, Sockets. List of Designating Letters.
MIL-STD-17	6 July 1950	*Military Standard Mechanical Symbols*. Topics: Mechanical Symbols for General Use, Mechanical Symbols for Aeronautical Use.
MIL-STD-18A	12 Aug 1953	(Superseding MIL-STD-18 7 June 1949) *Military Standard Structural Symbols*. Topics: Symbols for General Use, Reinforced Concrete Construction, Structural Steel and Aluminum Construction, Timber Construction.

Short title	Latest edition	Long title and contents
JAN–STD–19	13 Nov 1947	*Joint Army-Navy Standard for Welding Symbols.* Topics: Basic Symbols, Basic Types of Joints and Welds, General Provisions, Fillet Welds, Groove Welds, Bead Welds, Plug Welds, Slot Welds, Spot Welds, Seam Welds, Projection Welds, Flash and Upset Welds.
MIL–STD–20	14 Dec 1949	*Military Standard Welding Terms and Definitions.* Topics: Illustrations, Grouping of Terms.
MIL–STD–24	9 Mar 1951	*Military Standard Revision of Drawings.* Topics: Definitions, Changes in Dimensions, Revisions, Symbols, Recording Revisions on Drawings.
MIL–STD–103	18 May 1953	*Military Standard Abbreviations (For Electrical and Electronic Use).* Topics: Purpose, Form, Rules for Use, Alphabetical List of Terms.

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BLUEPRINT READING
and
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CHAPTER 1

MAKING AND HANDLING BLUEPRINTS

USE OF BLUEPRINTS

The ships, planes, and guns of the Navy were built from blueprints, and they are operated, checked, cleaned, and lubricated according to information found on blueprints. When mechanisms fail in service or are damaged in battle, blueprints are broken out to aid the repair crews. When new parts must be made in the shops, blueprints provide the necessary information.

HOW ARE THEY MADE?

Blueprints are exact copies of mechanical or other types of drawings.

A mechanical drawing is one made with instruments such as compasses, rules, and dividers. Blueprints, or prints, as they are often called, are made from these drawings in much the same way that photographs are made from negatives.

The negative for the blueprint is known as a TRACING. It is made by placing a sheet of translucent tracing paper or cloth over the drawing. Everything on the drawing is traced on the tracing paper or cloth with black waterproof ink or a special black pencil. After the tracing is completed, it is checked, and the original drawing is filed for future use. Some drawings are made directly on the tracing material in pencil and then traced with ink or with the special black pencil.

Next the tracing is placed in the blueprinting machine, with the face toward the source of light, and is covered with

blueprint paper. The sensitized side must also be toward the source of light which penetrates the tracing at all parts not covered by lines and causes a chemical action on the blueprint paper. There is no chemical action under the lines of the tracing because the black lines block off the light.

After proper exposure, the print is removed and washed in a developing solution and then in clear water. The exposed portions of the blueprint paper turn a deep blue during the processing. The lines are white.

Any number of prints can be made from one tracing if it is handled carefully.

BLUEPRINT COLORS

Blueprints aren't always blue. All kinds of reproduced drawings are commonly referred to as blueprints or just prints. They may be white, brown, black, gray, or other colors. The differences lie in the kinds of papers used and in the development processes.

BLACK-AND-WHITE PRINTS have black lines on a white background.

AMMONIA PRINTS, or ozalids, have black, maroon, purple, or blue lines on a white background.

VAN DYKES have white lines on a dark brown background.

PHOTOSTATS: negatives, with white lines on a dark background (used when only one print is needed); or positive, made from a negative photostat (when more copies are needed) and having dark lines on a light background.

Of these several ways of duplicating an original drawing you will find that the Navy has many more ammonia prints than any of the others. A print made by this process will be called "an ozalid" which is the trademark of one of the commercial ammonia processes.

TYPES OF BLUEPRINTS

Look at figure 1–1. Notice that the assembling begins with a DETAIL BLUEPRINT of the aileron rib. Then there's a SUBASSEMBLY BLUEPRINT. That shows how the aileron rib joins the other parts of the aileron assembly. Next is a UNIT ASSEMBLY BLUEPRINT. From it you can tell where

the aileron joins the other parts of the wing assembly. The FINAL ASSEMBLY BLUEPRINT shows the entire wing assembly in relation to the completed plane.

Many of our fighting ships are so large and have so many sections, divisions, compartments, passageways, and ladders that the members of the crew need maps to find their way around. These maps or blueprints are PLAN VIEWS and show position, location, and use of the various parts of the ship.

You will use plan views to find your duty and battle stations, the sick bay, barber shop, and tailor shop. Other

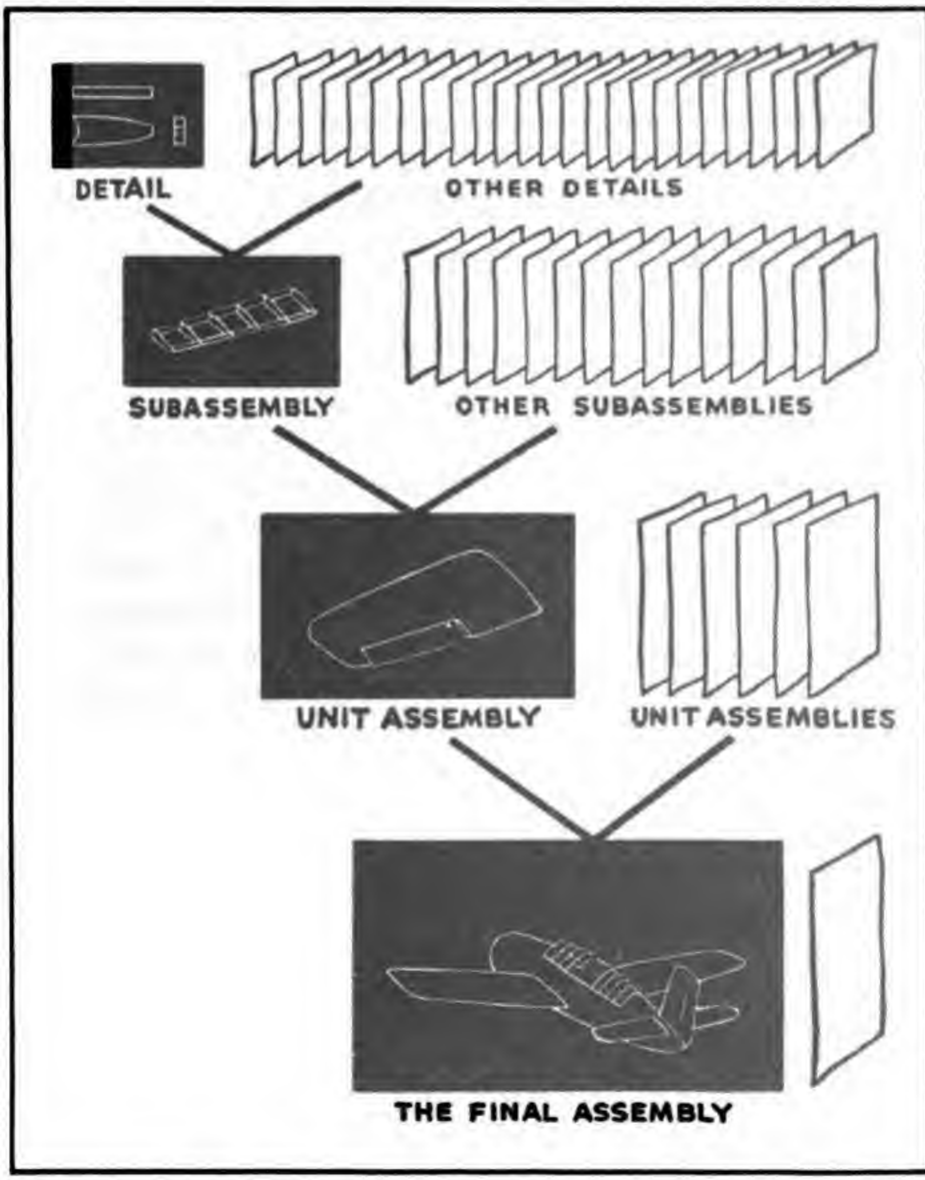


Figure 1–1.—Every part, every assembly has its descriptive print.

plan views will show the location of watertight doors and hatches, life rafts and boats, battle dressing stations, and firefighting equipment. Still others will show water mains, power lines, air lines, ventilating systems, drainage systems, and fire control systems.

When you are required to make a certain part you will use a DETAIL PRINT. This print will give you all the information you need to make a new part or piece. A detail sheet will show one large part or several small parts. It shows size, shape, kind of material, and method of finishing.

Remember that PLAN VIEWS serve as maps, that FINAL ASSEMBLY, UNIT ASSEMBLY, and SUBASSEMBLY PRINTS show how parts fit together, and that DETAIL PRINTS show everything needed to make a certain part or piece.

HANDLE WITH CARE

Blueprints are not just scraps of paper. They are valuable permanent records and can be used again and again if you take care of them. Here are a few simple rules for getting the best results from them:

1. Keep them out of strong sunlight—they might fade.

2. Don't allow them to get wet or grease-smudged.

3. Don't make pencil or crayon notations on a print without proper authority. If you should get instructions to mark a blueprint, use a yellow pencil. Ordinary (black lead) pencil marks are hard to see on a colored background.

4. Never measure distance on a blueprint. If you can't find a dimension on one view, look at another view. If you still can't find it, ask someone who knows. Why not measure? Because the original mechanical drawings might not have been drawn exactly to scale, or the print may have shrunk or stretched.

5. Keep your blueprints stowed in their proper place so that they can be readily located the next time you want to refer to them.

FOLDING BLUEPRINTS

A standardized, accurate system of filing blueprints is necessary in order that the prints may be found quickly.

Figure 1-2.—First fold, showing use of folding board.

To expedite the locating of blueprints, the Navy (and the other Services) has a standard method of folding blueprints. This insures that the identifying marks always appear in the same place, preferably at the top when the prints are in vertical filing order.

Most of the prints you will use will already be properly folded. Your only concern will be to see that they are refolded correctly. However, you may have occasion to use prints that have not been folded at all or that have been folded improperly. Such blueprints should be folded according to the following instructions:

1. All blueprints should be folded neatly in such a manner

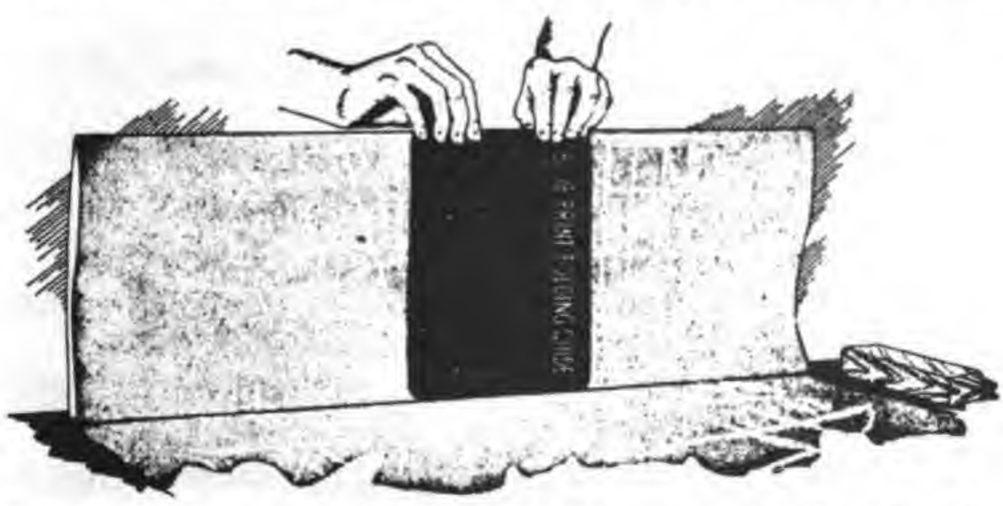


Figure 1-3.—Successive folds, like the first, measure 11 inches. The last fold may be less than 11 inches.

that the duplicate drawing number appears on the outside in the upper right-hand corner of the print. The fold size should be approximately 8½ inches by 11 inches (standard business letter size). The so-called "accordion-pleated form," with vertical folds as shown in figures 1–2 and 1–3, should be used.

2. A folding board is required for folding blueprints to the standard 8½ inches by 11 inches. This board, of sheet metal, plastic, or plywood, should be 8⅜ inches by 10⅞ inches and should have its corners rounded.

3. A creasing device, that is, a smooth block of wood, metal, or plastic, or a glass paperweight, should be used to press the folds into LIGHT creases. (See fig. 1–4.)

Figure 1–4.—The width is folded in 8½-inch folds.

4. On the following sizes of blueprints straight folds or no folds will be used as indicated:

Size in inches	*Type of fold*
8½ x 11	Blueprint already desired size. No fold required.
11 x 17	Fold once to 8½ x 11 inches.
17 x 22	First fold to 17 x 11, then to 8½ x 11 inches.
22 x 34	First fold to 34 x 11, next to 11 x 17, then to 11 x 8½ inches.
11 x 34	First fold to 11 x 17, then to 8½ x 11 inches.

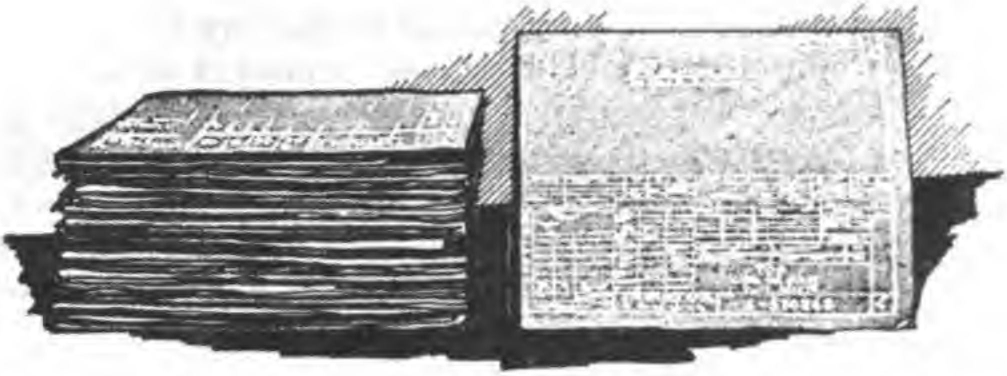


Figure 1–5.—Duplicate drawing number and change are shown in upper right-hand corner.

5. On all roll-size blueprints (that is, on all prints except those of the sizes listed above) the accordion fold is made by use of the folding board. In each case the first fold (fig. 1–2) is made from the end that carries the drawing number, and it is an 11-inch fold. Each fold thereafter (fig. 1–3) is 11 inches, except the last, which in some cases may be less. After the LENGTH of the print has been folded down into the required number of 11-inch accordion folds, the WIDTH is folded in 8½-inch folds. (See fig. 1–4.) These may be rolled or straight folds.

6. When the duplicate drawing number or numbering area fails to appear on the face of a print, all such prints should be folded face side or printed side in, so that the print number is on the underside of an outside fold and can be seen when you raise one corner of the blueprint. (See fig. 1–6.)

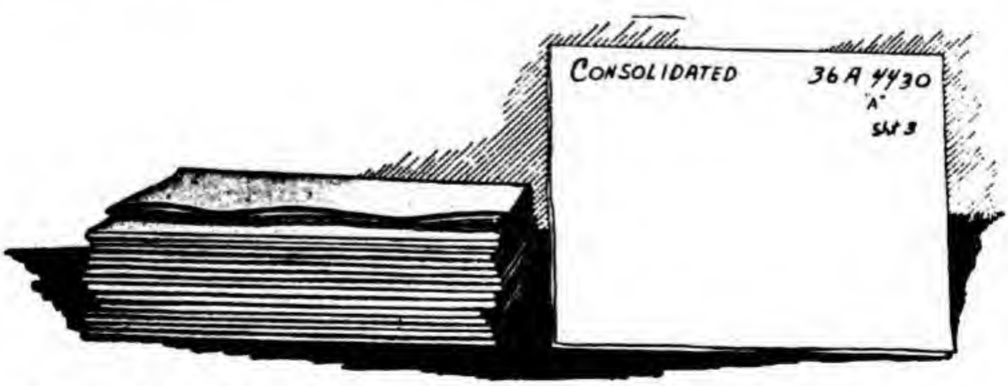


Figure 1–6.—Contractor's name provides further identification on a print.

7. Specifications for blueprints to be used by the Armed Forces require that the blueprints be so marked as to have the identifying information visible when the prints have been folded as prescribed in this section. However, some blueprints may be folded according to other procedures, depending on the usages of the manufacturer. In such cases the proper information should be marked or stamped on the print as necessary. (See fig. 1–6.)

QUIZ

1. Which blueprint would represent a later step in the construction of an object—a unit assembly or a subassembly?
2. Blueprints are used to save mechanical drawings. What kind of care must you exercise to save blueprints?
3. If a necessary line dimension were missing from your blueprint, why couldn't you just measure the line on the blueprint?
4. Why is it necessary to have a standard method of folding blueprints?
5. What kind are most Navy prints?
6. What do the lines on a tracing do when the exposure is being made?
7. When a tracing is used to make a print, it is being used as a ________________.
8. Where no light reaches the sensitized paper beneath the lines on the tracing, how much chemical action takes place due to the absence of light?
9. Where light reaches the sensitized blueprint paper, what do the subsequent development and washing do?
10. How many blueprints can be made from one tracing?
11. A negative photostat, with __________ lines on a __________ background, is used when only one print is needed.
12. A positive photostat, with __________ lines on a __________ background, is used when ________________.
13. From what is a positive photostat made?
14. What is the trade name of the commercial ammonia process generally used in the Navy?

CHAPTER 2

BLUEPRINT VIEWS

PHOTOGRAPH OR BLUEPRINT?

A photograph of an object gives you a good idea of its shape and the relationship of its various parts. It may show its exact size. The camera brings all visible parts into one picture view on one plane. It records pictures of objects much as your eyes see them. But the camera picture is deceptive, just as your eyes are deceptive.

Just recall the last time you looked down a straight stretch of railroad. Your eyes told you that the tracks came together at a distant point, but you knew the tracks were parallel, so you didn't believe your eyes. Because the camera records this deceptive appearance, photographs cannot be used where accurate blueprints are necessary. The lines on a photograph do not register directly the true length and shape.

Photographic blueprints are valuable visual aids when used to show general location, function, and appearance of parts and assemblies. They are often used to show the special characteristics of parts, as in figure 2–1.

Operation steps are often shown by a series or sequence of photo prints. You may learn to take a mechanism apart and reassemble it by using photo prints as a guide.

EXPLODED VIEWS

Another valuable use of the photo is for exploded views that show locations of parts. Figure 2–2 shows two exploded views of the .45-caliber automatic pistol. Notice how the

Figure 2–1.—Exterior characteristics of .45-caliber automatic pistol.

parts are spread out in line to show clearly each part's relationship to the other parts.

PERSPECTIVES

Often it is desirable to have a picture of a new type of craft or machine before such an article has been manufactured. The draftsman can use his mechanical drawing tools to create these pictures. Figures 2–3 is an example of such a drawing.

These substitute pictures are called PERSPECTIVES. On a perspective lines that are actually parallel on the object would run together if extended on the drawing. Perspectives are excellent substitutes for photographs and may be used in the same manner, but you will not use either of them for construction or repair blueprints.

In figure 2–3 notice the length of the left and right wings. They are actually the same length, but if you measure them on the picture, you will find one shorter than the other. In order to draw the airplane as it appears to the eye, the artist FORESHORTENED the wings.

THE ISOMETRIC

The isometric is somewhat like both the photograph and the perspective. However, on isometric lines that are

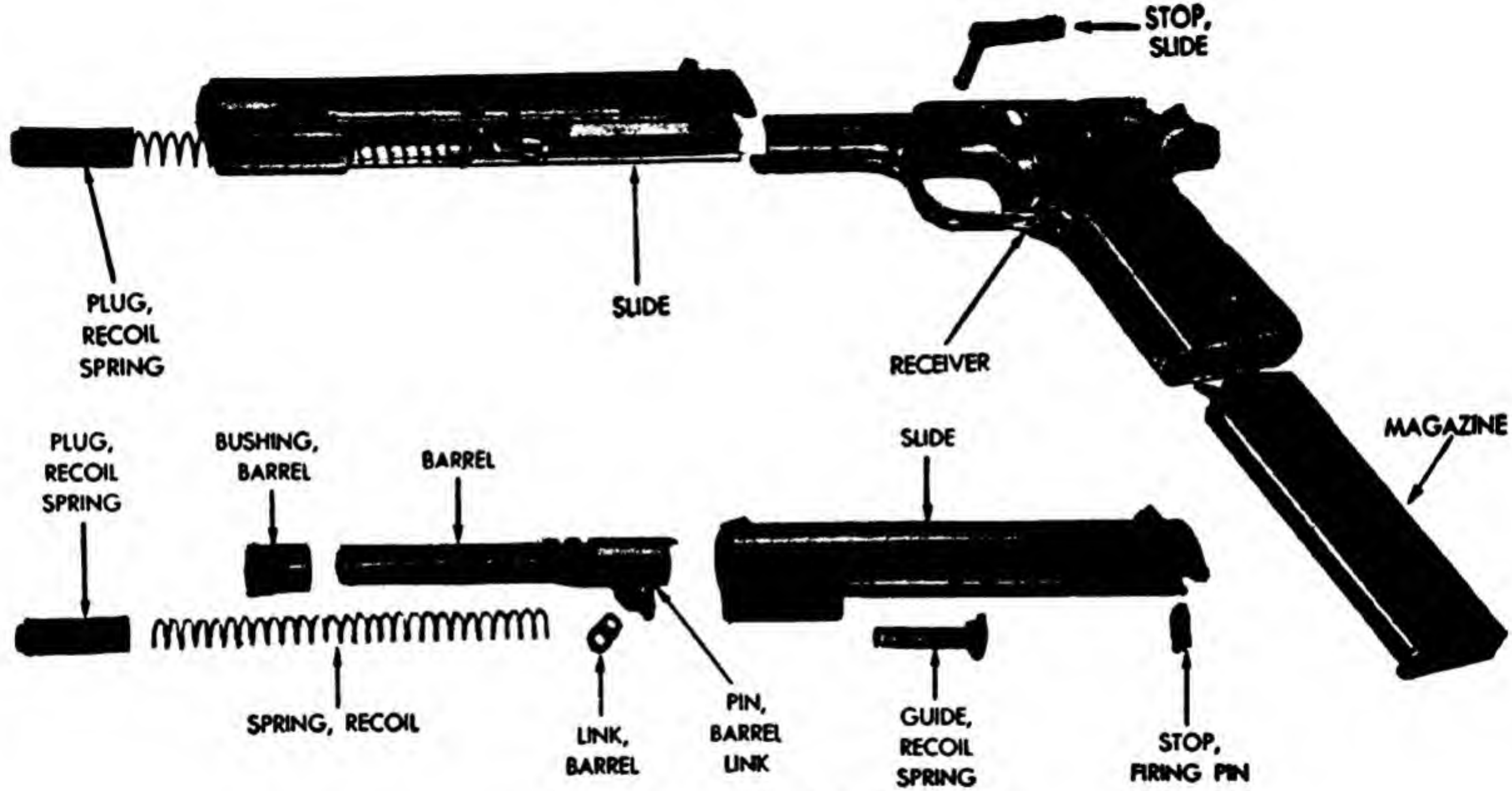


Figure 2-2.—Exploded views.

Figure 2-3.—A perspective, like a photograph, does not give true lengths.

actually parallel on the object would also be parallel on the drawing and would, therefore, NOT run together if extended on the drawing. All its lines representing horizontal and vertical lines on an object have true length. Vertical lines are shown in a vertical position, but lines representing horizontal lines are drawn at an angle of 30° with the horizontal. Vertical lines and lines representing horizontals on such drawings are known as ISOMETRIC lines. In figure 2-4 all

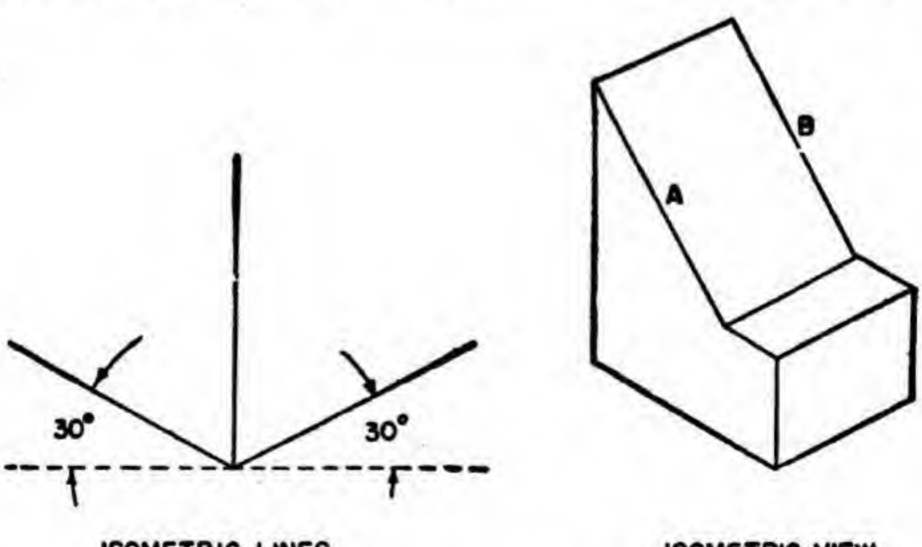


Figure 2-4.—Isometrics.

lines except A and B have true length because they are horizontal and vertical lines on the object. Lines *A* and *B* are not isometric lines, and their lengths are not true.

Isometrics (fig. 2–5) have much the same use as other picture drawings. In addition, they may be dimensioned, and blueprints of these drawings may be used for making simple objects. But isometrics cannot be used alone for

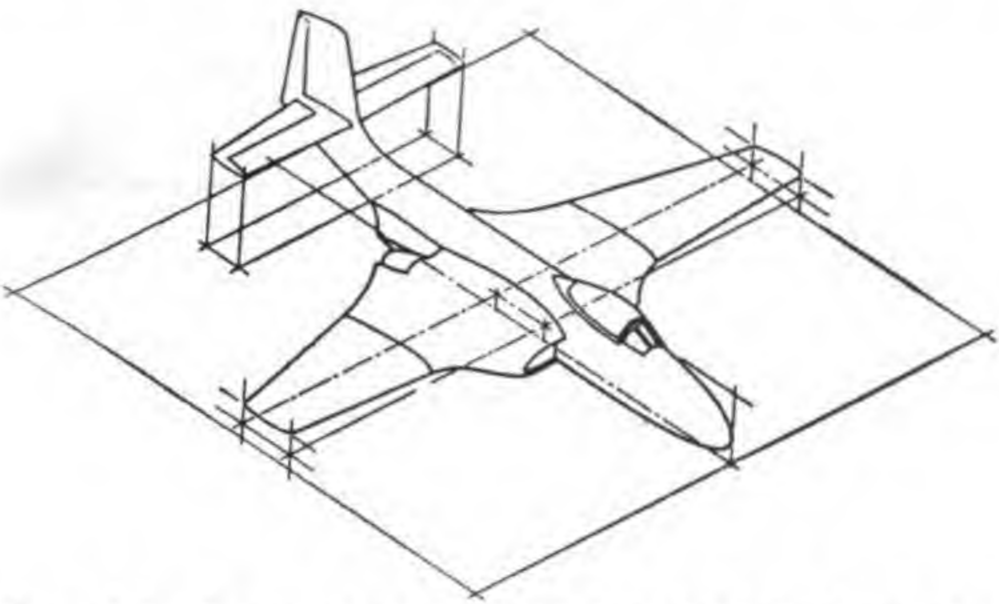


Figure 2–5.—An isometric view is the draftsman's trick for showing three views at once in dimension, but the object is distorted.

complicated parts or structures. They may be used as an aid in clarifying the accurate orthographic drawings that are the foundation of all construction blueprints.

ORTHOGRAPHICS

Blueprints that furnish complete information for construction and repair present an object in its true proportions. Such prints are copies of mechanically drawn ORTHOGRAPHIC views. These views are accurate and indicate true shape and size.

When you study orthographics, look at one view at a time. To get a good idea of a PT boat, for example, you must look at it from either port or starboard, then from dead

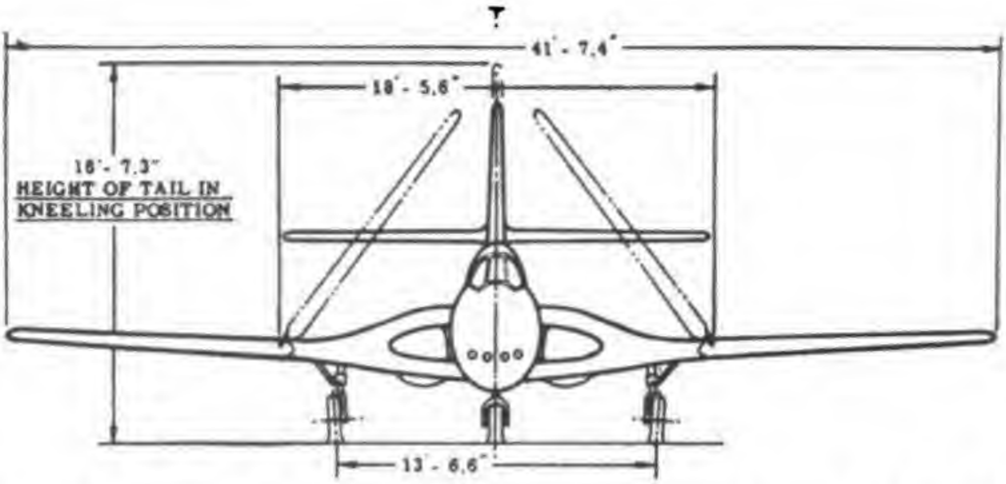


Figure 2–6.—Front view, from an orthographic drawing, showing true view of the object's dimensions.

ahead or astern, then from topside. By observing from several points you can obtain a clear understanding of the whole boat. This is the basic principle of orthographics.

You can see a surface of an object in its true shape and size only by looking directly at that surface, as is shown in figure 2–6. Your line of sight must be perpendicular to the surface at all points on the surface. Only then can you tell the true size and shape of each surface. When these views of the various surfaces are placed on paper, their proper relationship is maintained by the proper arrangement of the views.

ORDERLY VIEW ARRANGEMENT

Study the arrangement of the three views in figure 2–7. The front view (lower left in figure 2–7) is the starting place. It was selected for the front view because it shows the most characteristic feature of the object—the notch.

The right side view is projected directly to the right of the front view. Some of the lines on the right side view lie along extensions of lines on the front view.

Notice that the top view is placed directly above the front view and that some of its lines lie along extensions of lines on the front view.

After you study each view, try to imagine or visualize

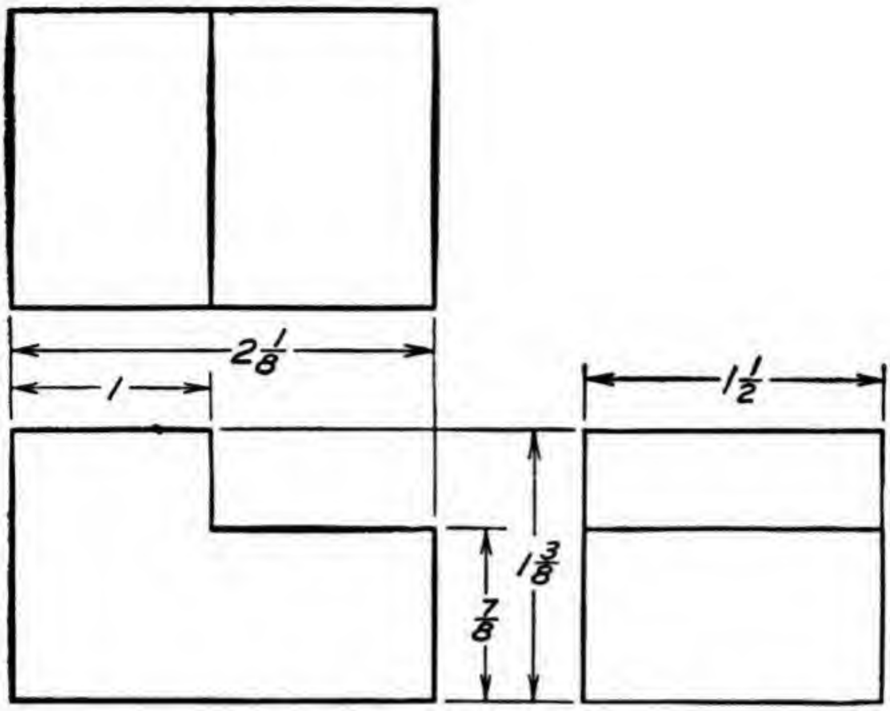


Figure 2–7.—The orthographic views.

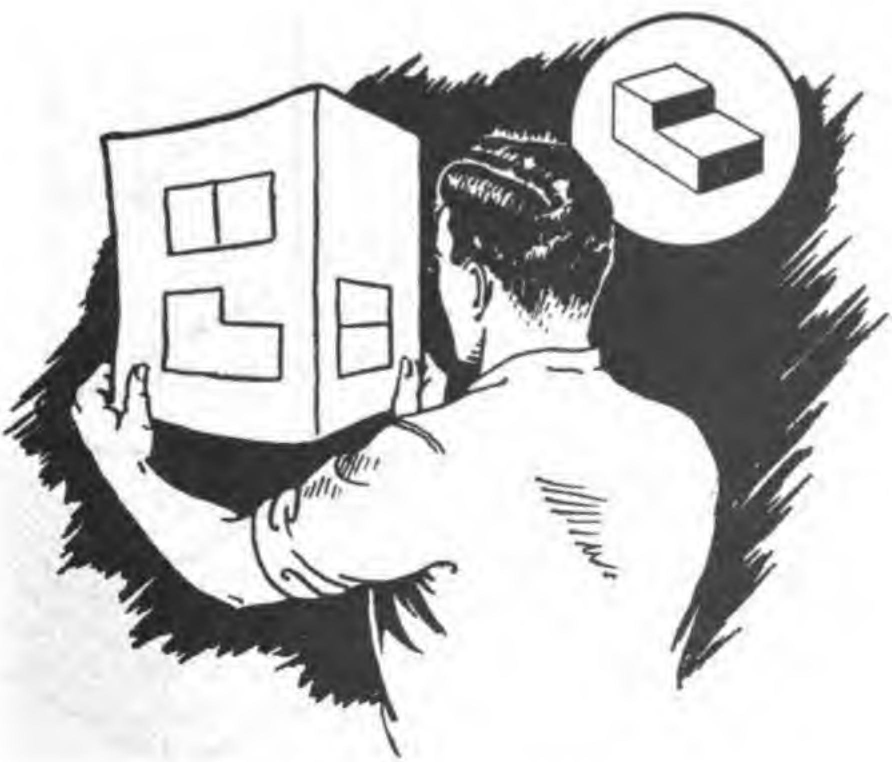


Figure 2–8.—Visualizing a blueprint.

Figure 2-9.—Compare the orthographic views with the model.

the appearance of the object. If you have trouble, use the methods shown in figures 2-8 and 2-9.

Fold the sheet between the front and right side views. That will give you a rough idea of the shape of the object

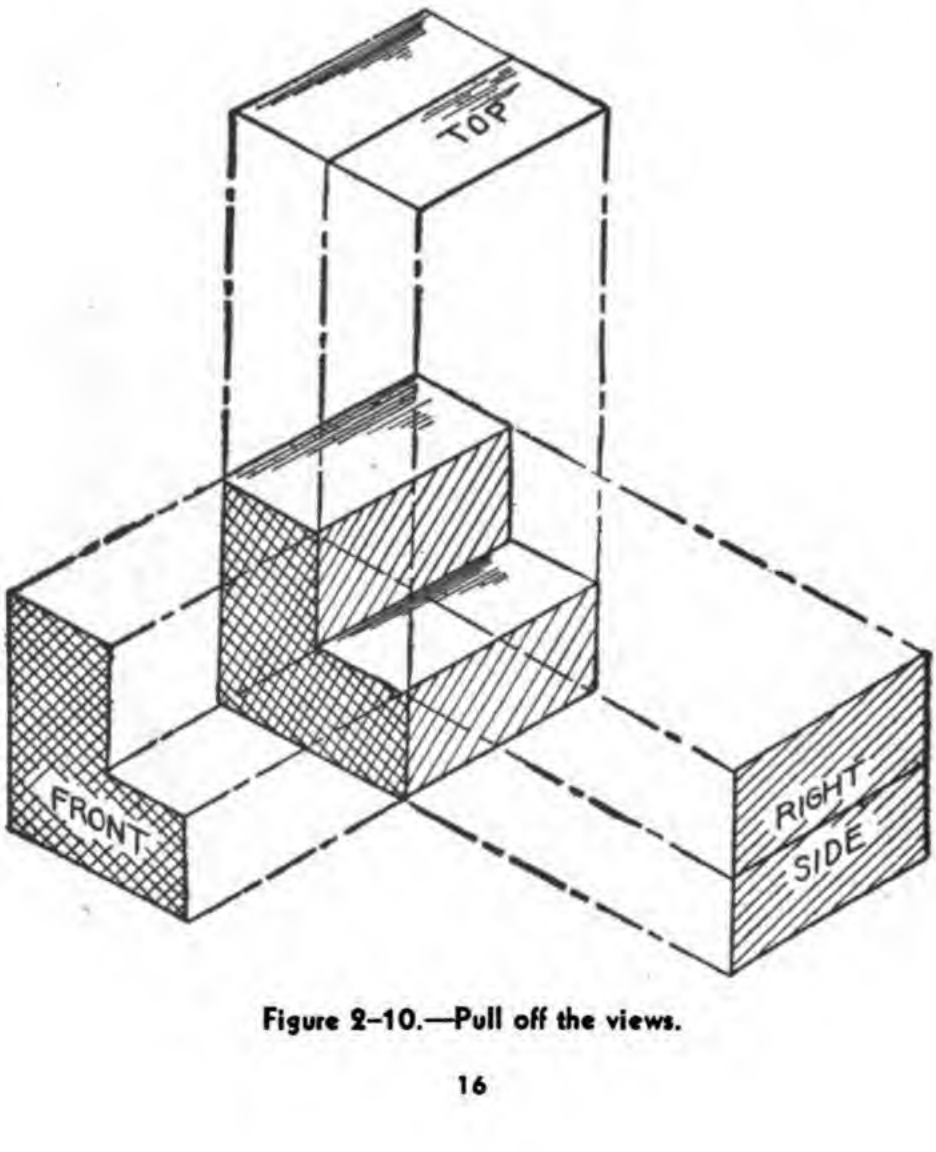


Figure 2-10.—Pull off the views.

as it appears in three dimensions. Figure 2-10 shows how the views are "pulled" from the object.

Think of the object as being immovable, and pretend that you are moving around it. This will help you to relate the blueprint views to the appearance of the object concerned.

AUXILIARY PROJECTION

Look directly at the front view of figure 2-11. Notice the inclined surface. Now look at the right side view and the top view. The inclined surface appears foreshortened—not

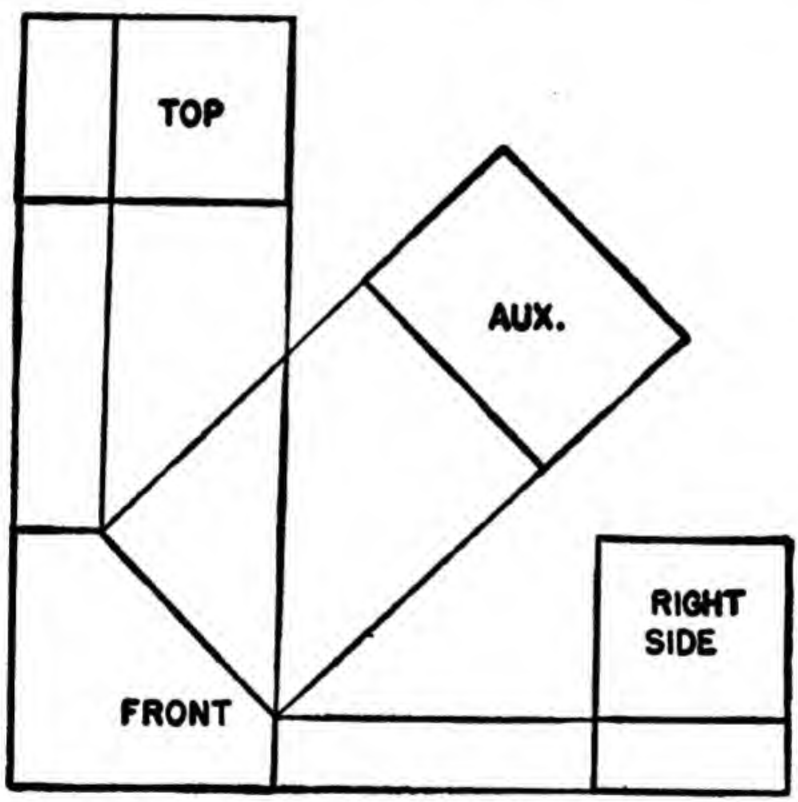


Figure 2-11.—Auxiliary view arrangement.

its true size. For a case like this the draftsman uses a special helping view known as an AUXILIARY. It is obtained by looking directly at the inclined surface. This orthographic auxiliary provides a reliable view of an inclined surface. The principle of the auxiliary is shown in figure 2-12. For a side by side comparison of an orthographic

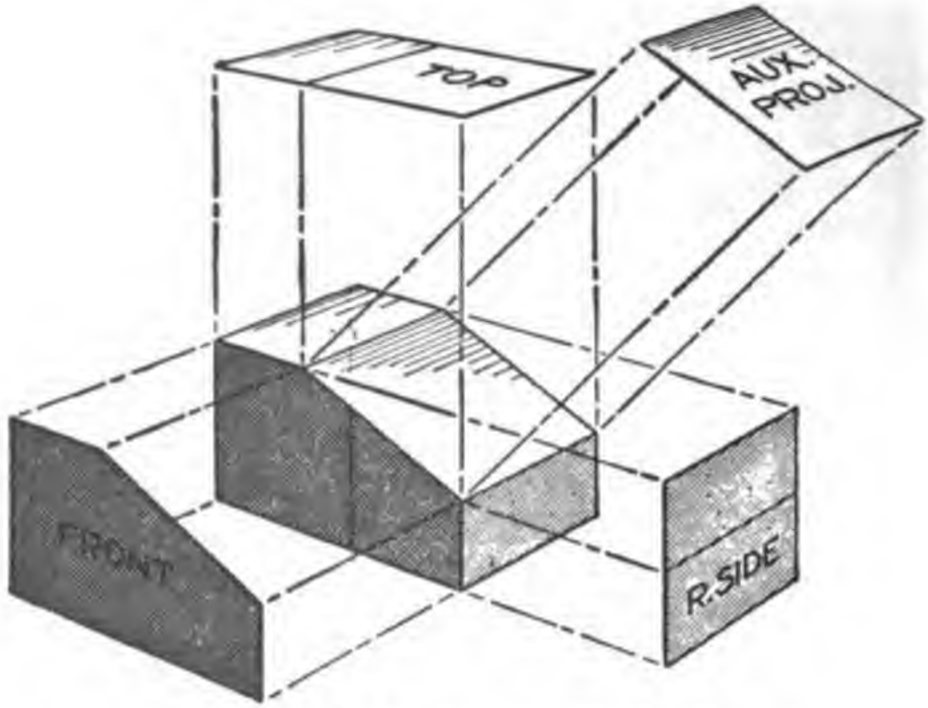


Figure 2-12.—Auxiliary projection principle.

view and an auxiliary projection, see figure 2–13. You will see a foreshortened orthographic view in 2–13a of the slanting surface whose true size and shape are shown projected as an auxiliary projection in 2–13b.

CURVED SURFACES

Curved surfaces do not always look curved in an orthographic drawing. This is because you are looking at the top, bottom, or side of the object at 90° to the surface,

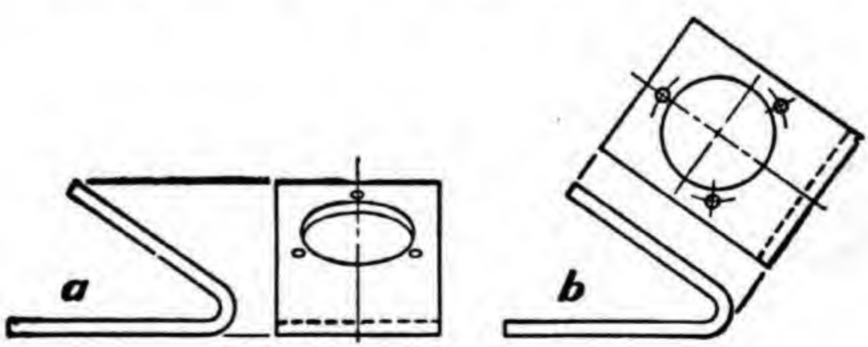


Figure 2-13.—Comparison of orthographic and auxiliary projection.

or squarely at it. You often see curved edges which indicate a curved surface behind them, but when you see the surface itself in another view, you see it as a broadside and it appears flat.

Figure 2–14 is a two-view orthographic drawing of a solid cone. A third view, which would ordinarily appear above the bottom view (making it a three-view orthographic) is not necessary in this drawing as it would only duplicate the side view shown at B and give no additional information.

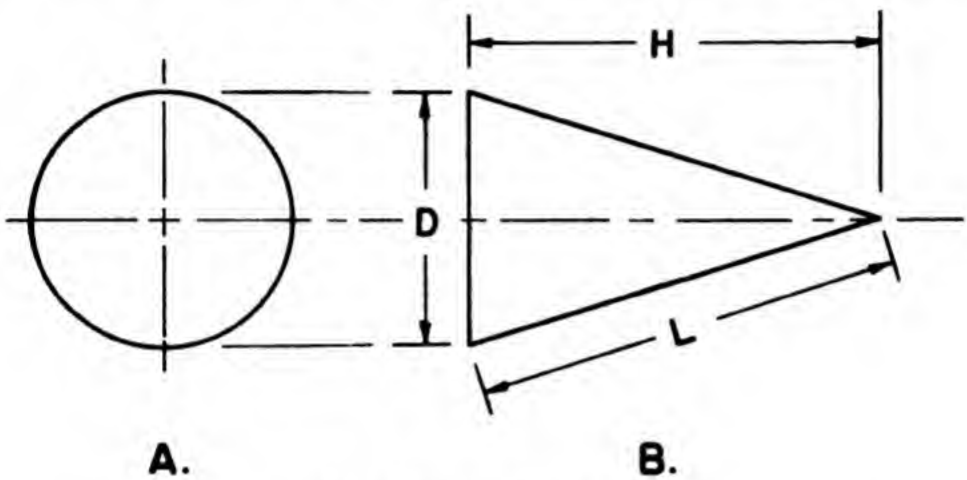


Figure 2–14.—Solid cone.

You know that the side of a cone is curved, but you cannot see that curvature in figure 2–14B. You see the bottom edge of this curved side in figure 2–14A so you know that it does exist. It is a good idea to keep in mind the fact that curves in orthographic drawings do not show curved surfaces but may indicate a curved surface behind them and it is up to you to find that surface on one of the other views.

DEVELOPMENTS

Development is a method a layout man uses to make a flat pattern which can be transferred to sheet metal and formed into a curved or angular form. The Metalsmith does a great deal of this but men of most ratings will benefit by knowing even a little something about development from a blueprint reading point of view.

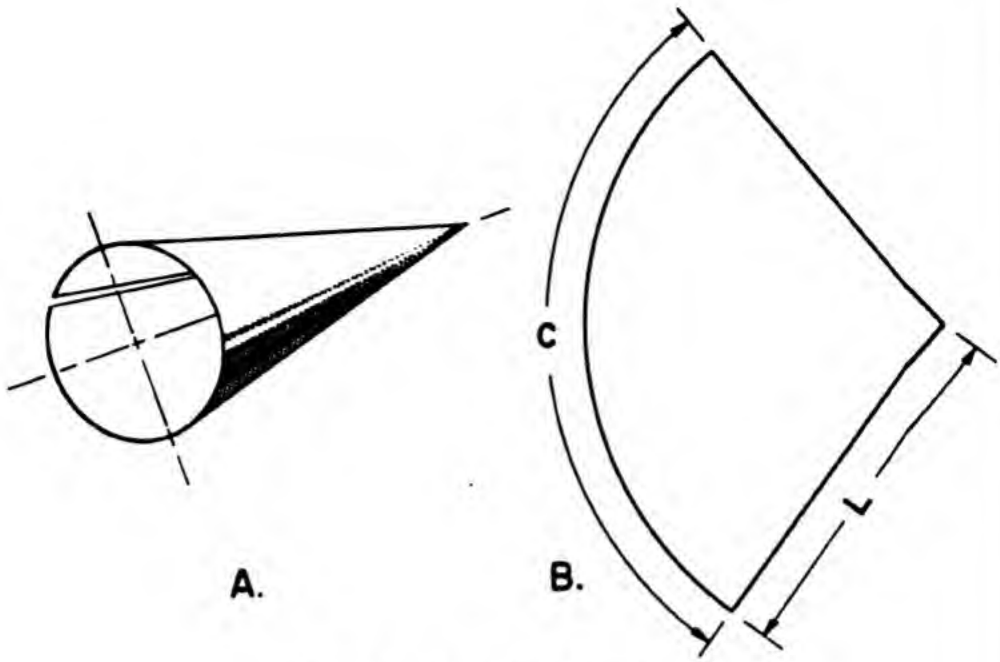


Figure 2–15.—Sheet metal cone.

In figure 2–15A you see a perspective view of a sheet metal cone. As the cone has no bottom, we can look up into it and see the joint which has purposely been left open for this illustration. To find out how the development or pattern for this cone would look, see figure 2–15B. The length of the side of the cone (not the height from base to top) is represented on the development as L. The circumference of the base of the cone is represented by the curved dimension line and the letter C. The stretchout at B in the figure (stretchout is another name used interchangeably with pattern or development), when rolled up, would give you the cone shown in A. Likewise, you could transfer the stretchout to sheet metal, run the metal through a slip roll forming machine, and you would have a sheet metal cone.

Looking again at figure 2–14A and B, which of course for a particular cone would have certain dimensions, see how you could get the information necessary to make the development for a sheet metal cone.

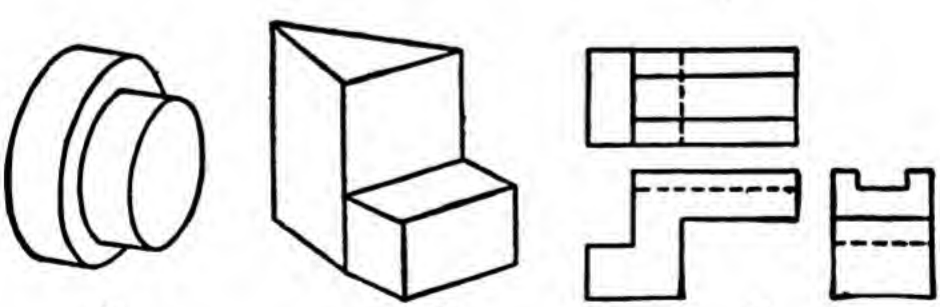
From 2–14B you would get the length of the side of the cone, or L, also shown in figure 2–15B. To make the de-

velopment you would use a compass set to L and draw part of a circle.

From 2–14A you would get the diameter of the base. This would enable you to calculate the circumference of the base which is C in figure 2–15B. Then you would step off C on the circle and draw the line back to the other end of L to form the pie-shaped pattern. You see now not only the difference between a development and an orthographic drawing, but also how each is related to the other and how they complement each other in showing a blueprint picture of an object with curved surfaces.

QUIZ

1. Why can't you use a photograph of an object as a blueprint when you make a replacement part for a machine?
2. What is clearly shown in an exploded view?
3. What lines of an isometric drawing are true in length?
4. When are mechanical perspectives used?
5. Why are orthographic drawings universally used as blueprints for construction?
6. What type of surface requires an auxiliary projection?
7. Sketch two orthographic views of A, three orthographic views of B, and an isometric of C.



A B C

8. To draw a perspective of an object, you must ____________ some of its features.
9. On an isometric drawing lines that are parallel on the object (would—would not) be parallel on the drawing. (Select one.)

10. Isometric drawings (may—may not) be dimensioned.
11. The foundation of all construction blueprints are (orthographic drawings—isometric drawings).
12. In an isometric vertical lines are shown in a____________position.
13. In an isometric lines representing horizontal lines are drawn at an angle of________with the horizontal.
14. When looking at a surface to see its true size and shape for an orthographic view, your line of sight must be____________to the surface at all points on the surface.
15. How many views could you expect to find in an orthographic drawing?
16. Orthographic views indicate true__________and__________.

CHAPTER 3

LINES AND SECTIONS

DRAFTSMAN'S LANGUAGE

The draftsman's drawings are composed of lines of different construction, each line with a special meaning. Lines are indeed the "common words" of the draftsman—he draws his language. Because he must place a large amount of information in a small space, he uses as few words as possible.

The lines on drawings and blueprints are standardized. You need to learn the appearance and use of these lines to be able to understand blueprints.

LINE USE

A basketball court is laid out with lines—there are boundary lines, center circle lines, and free-throw lines. The basketball court is really a full-size, top-view orthographic made with lines. The lines may be of different lengths, widths, colors, and shapes for different uses. This same principle is used on mechanical drawings. On a blueprint the draftsman uses OUTLINE LINES. They correspond

OUTLINE

to the boundary lines of the basketball court. These heavy solid lines represent the edges and surfaces that are visible from the angle at which the view is drawn. You wouldn't be able to identify an object without the outline lines.

If you could look right through an object you would see

other lines in the object and on the back surface. To represent these invisible lines the draftsman uses a medium-weight broken line. It is a series of short dashes, all of the same length.

HIDDEN LINE

These dashed lines are called HIDDEN LINES. They represent edges of surfaces behind the view which is represented by the regular outline lines. Both of these kinds of lines are shown in figure 3–1. Notice that these two types of lines form the backbone of the drawing.

ALTERNATE POSITION LINES show possible alternate positions of moving parts. The lever in figure 3–1 is shown in a right-hand position. But the alternate position lines tell you that it moves to the left, swinging through an arc of 60°. The dashes of this line are the same weight as hidden lines, but they are twice as long.

ALTERNATE POSITION LINE

To locate the center of a circle or arc, CENTERLINES are used. They're also used to divide drawings into equal or symmetrical parts. You'll find these lines helpful in dimensioning and lining up views. Notice that the centerline is a lightweight line with alternate long and short dashes. Centerlines are always used to locate the center of a round hole.

CENTERLINE

Size is indicated on drawings by dimensions. Navy blueprints are usually dimensioned in inches. Size dimensions are placed in a break in the DIMENSION LINE. Some dimensions are placed between arrowhead tipped lines. In either case, the dimension distance is from the point of one arrowhead to the point of the other arrowhead.

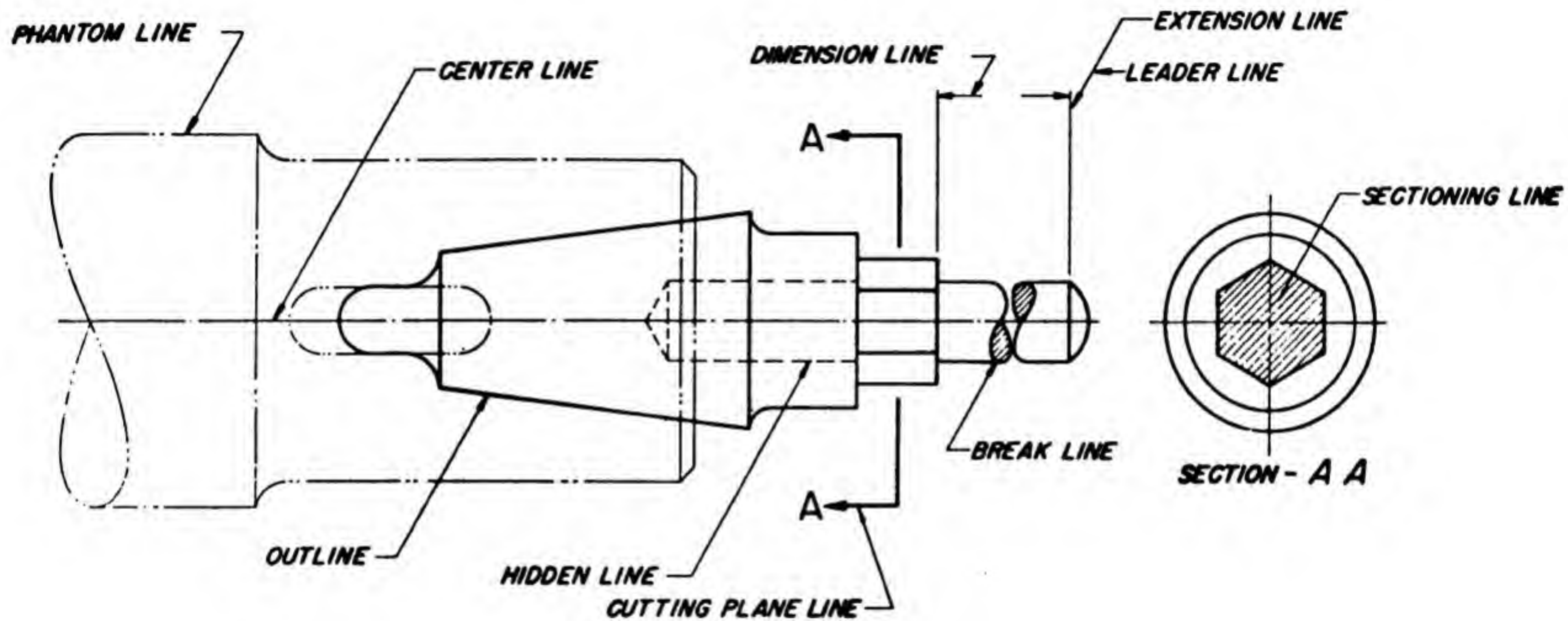
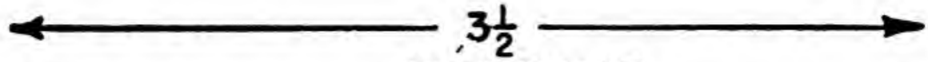


Figure 3-1.—Use of lines.



DIMENSION LINE

To keep the dimensions clear of the view, they are placed outside the view. Sometimes it may be necessary to put dimensions inside the outline, but it's better practice to keep them outside. EXTENSION LINES, light in weight, extend from lines of the outline. They are started about one-sixteenth of an inch away from the view outline.

LEADERS

Notice how the different kinds of lines are labeled in figure 3–1. Each name is tied to the proper line by a LEADER. Leaders composed of straight ruled lines should be used to indicate exactly where dimensions and dimensional or explanatory notes are to be applied. The note end of the leader should always run either to the beginning or end of the note or dimension, never to the middle. In general, the leader should be applied on the drawing view which shows the profile of the surface to which the requirement applies. Drawings will present a better appearance if all adjacent leaders are drawn parallel. However, leaders should not be parallel to adjacent dimension or extension lines. Leaders drawn to symmetrical features should be in line with the center of the feature and the arrowhead of the leader should terminate exactly on the line which represents the profile of the feature.

Sometimes the draftsman is cramped for space. If he drew the whole object, he would either run off the paper or have undersize views. So he uses LONG BREAK LINES to tell

LONG BREAK LINE

you that he has shortened that part. The long break line is simply a space saver for the draftsman; it does not change the actual length indicated by the dimension.

SHORT BREAK LINE

SHORT BREAK LINES tell you that the draftsman has removed part of an outer surface to reveal the inside structure. You will find that short break lines usually come in pairs.

BEND LINES

To indicate where thin metal is to be bent, the draftsman uses BEND LINES. Some draftsmen place dots on the line instead of the note "Bend here."

LINE CHARACTERISTICS AND CONVENTIONS

Learn to distinguish lines by their weight, or width, which may be HEAVY, MEDIUM, or LIGHT. Figure 3–2 shows the weights of the lines you have learned in this chapter. Train your eyes to recognize these kinds of lines by sight.

INSIDE SECTIONS

When you first see a new type of boat, ship, or plane, you like to look inside to see how it's made. A SECTIONAL VIEW allows you to "look inside" an object shown on a blueprint. One of the views is shown just as if you had sawed the piece in half along the cutting plane.

Notice the CUTTING PLANE LINE AA in figure 3–3A. It shows where the imaginery cut has been made. The isometric in figure 3–3B helps you to visualize the cutting plane. The arrows point in the direction in which you are to look at the sectional view.

Figure 3–3C is a front view showing how you would see the object if it were actually cut in half.

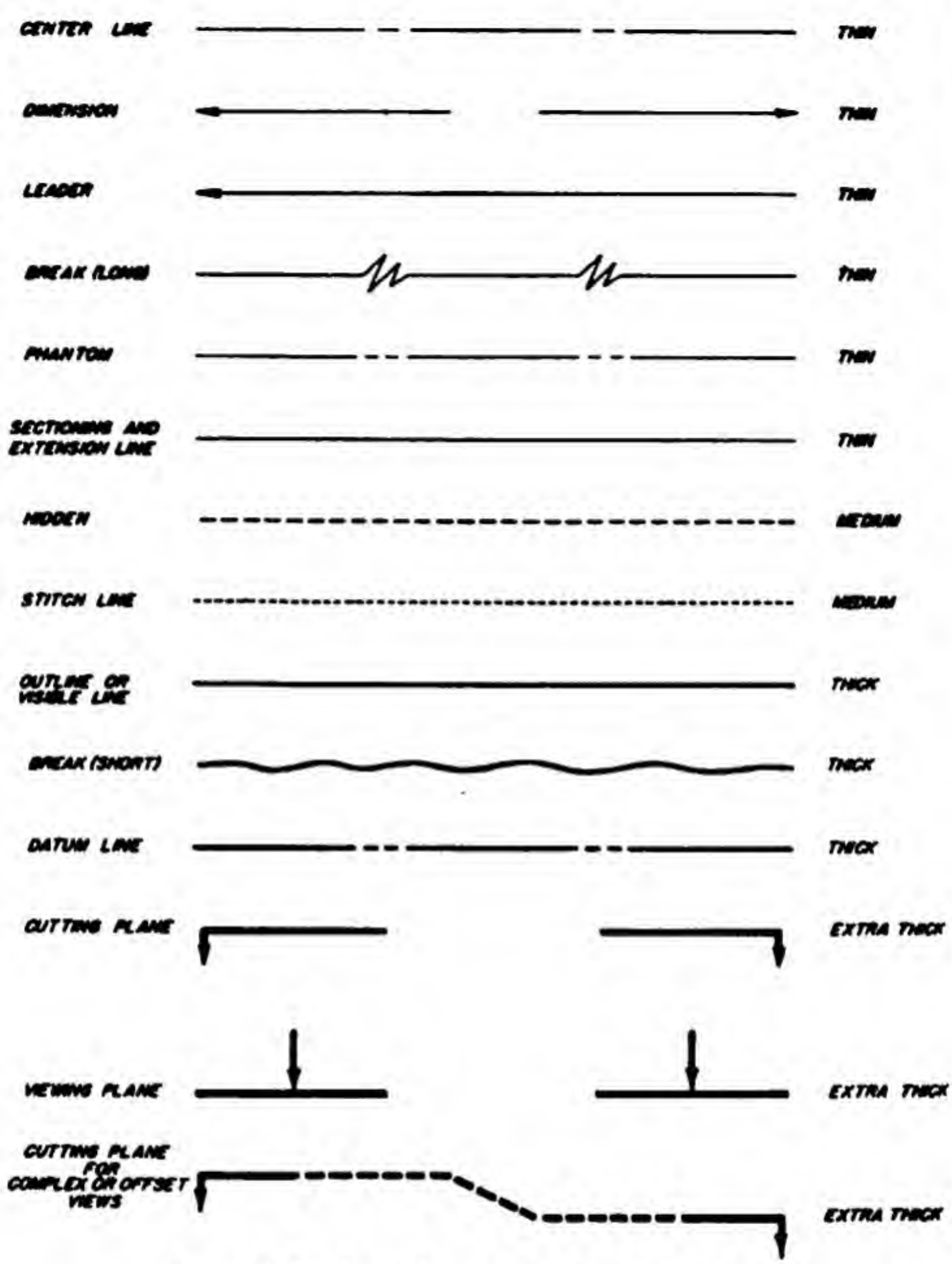


Figure 3–2.—Line characteristics and conventions.

The orthographic view of section A-A, figure 3–3D, is placed on the drawing instead of the confusing front view in figure 3–3A. Notice how much easier it is to understand.

When sectional views are made, the part that is cut by the cutting plane is marked with diagonal, parallel SECTION LINES. The draftsman's word for the process of making

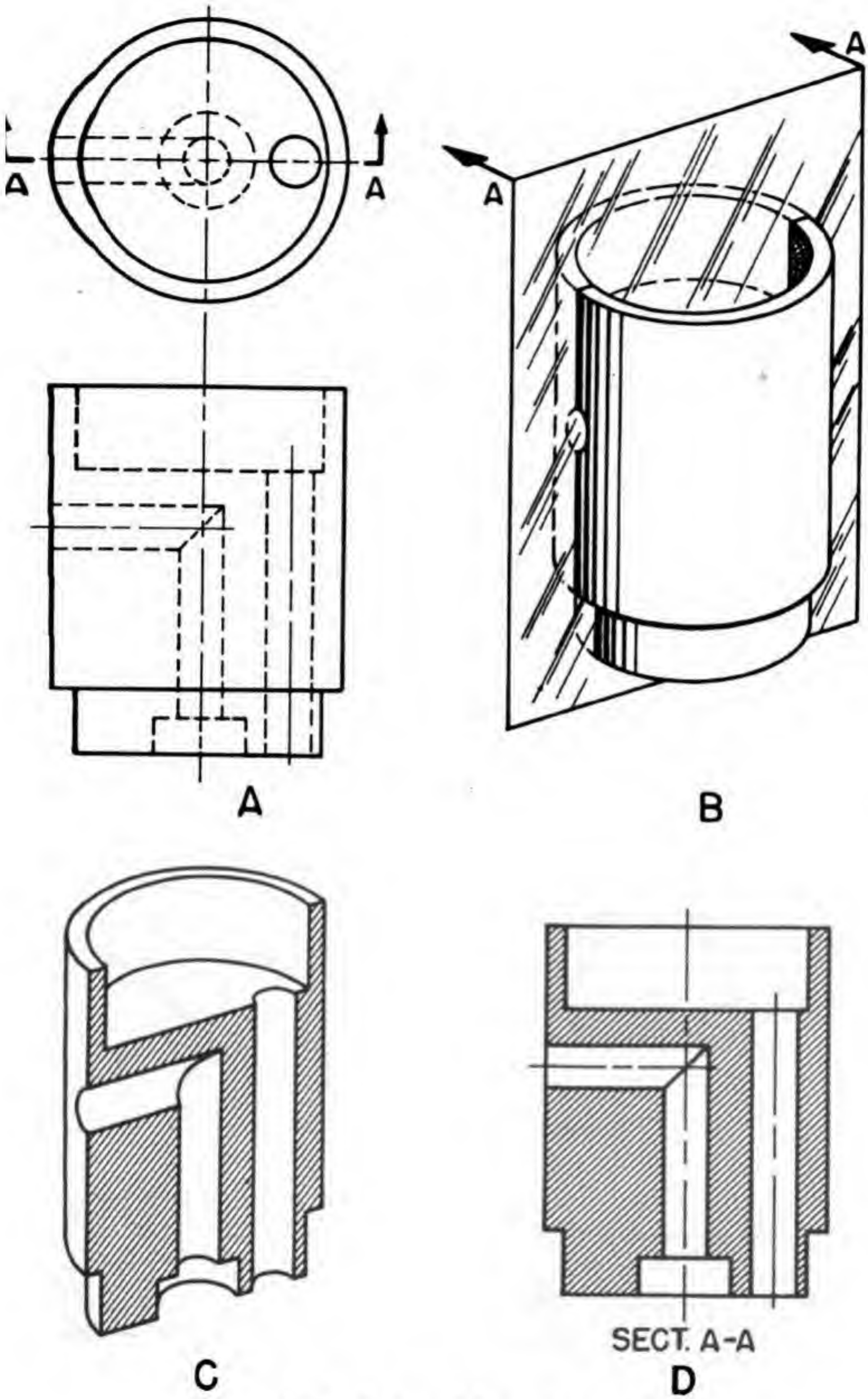


Figure 3–3.—Action of the cutting plane.

these lines is CROSSHATCHING. When two or more parts are shown on one view, each part is sectioned or crosshatched with a different slant of line. Section views are necessary for a clear understanding of complicated parts. On simple drawings a section may serve the purpose of an additional view.

Section *A-A* in figure 3–3D is in FULL SECTION because the object is cut completely through. You won't always see a full section. But there are other sections to help you to look inside. They are discussed in the next few pages.

OFFSET SECTION

In an OFFSET SECTION you have a joggle or offset in the cutting plane. The offset cutting plane in figure 3–4 is arranged so that the hole on the right side will be shown

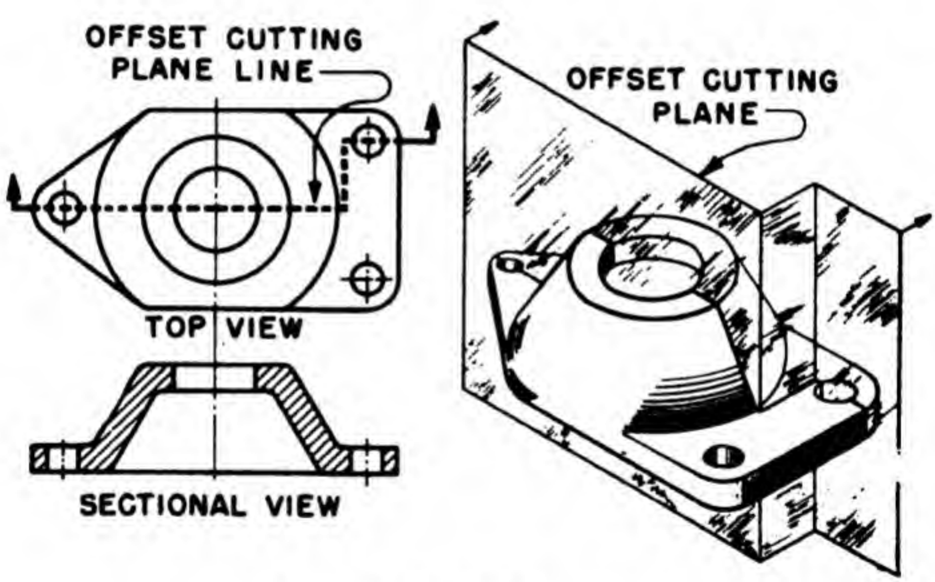


Figure 3–4.—Offset section.

in section. The sectional view is the front view, and the top view shows the offset cutting plane line.

HALF SECTION

Figure 3–5 shows a HALF SECTION. A half section is used when the object is symmetrical in both outside and inside

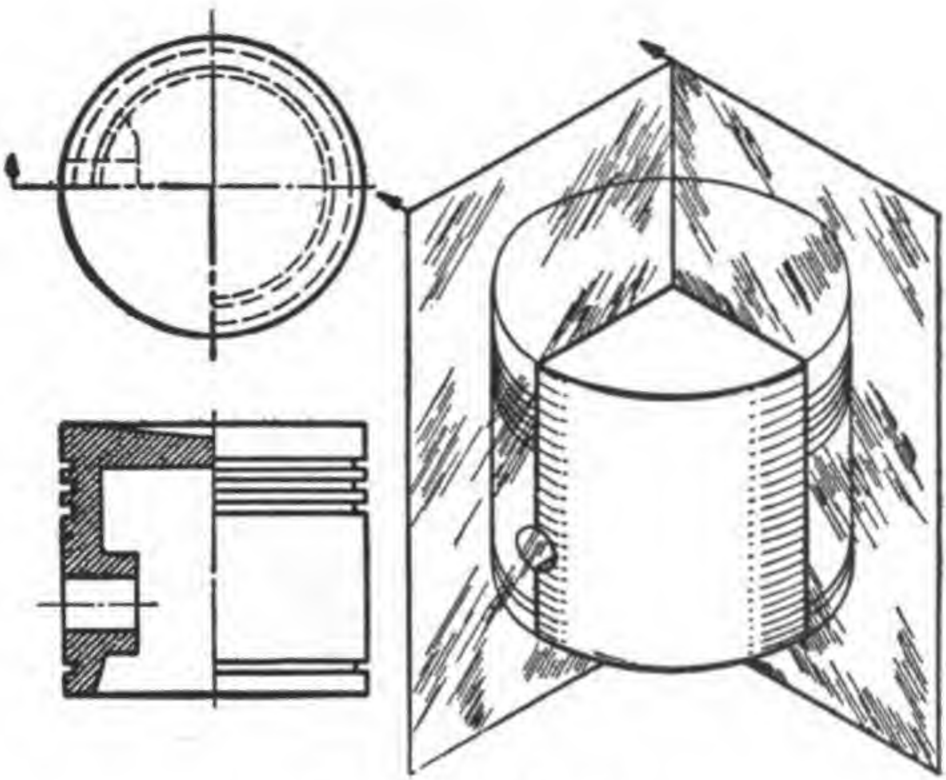


Figure 3-5.—Half section.

details. One half of the object is sectioned; the outer half is shown as a standard view.

The object is round, and if you cut it into two equal parts and then divide those parts equally, you'd have four quarters. Now remove a quarter.

That's what the cutting plane has done in the perspective. It has taken a quarter of the cylinder away so that you can look inside. If the cutting plane had extended along the diameter of the cylinder, you would have been looking at a full section. But the cutting plane in this drawing extends the distance of the radius, or only half the distance of a full section. Hence it is called a half section, rather than a quarter section.

The draftsman has inserted an arrow to show your line of sight. What you see from that point is drawn as a half section in the orthographic view. The width of the orthographic view represents the diameter of the circle. One radius is shown as a half section, the other as an external view.

REVOLVED SECTION

To eliminate drawing extra views of rolled shapes, ribs, and similar forms, the draftsman uses a REVOLVED SECTION. It is really a drawing within a drawing, and it clearly describes the object's shape at a certain cross-section station or point.

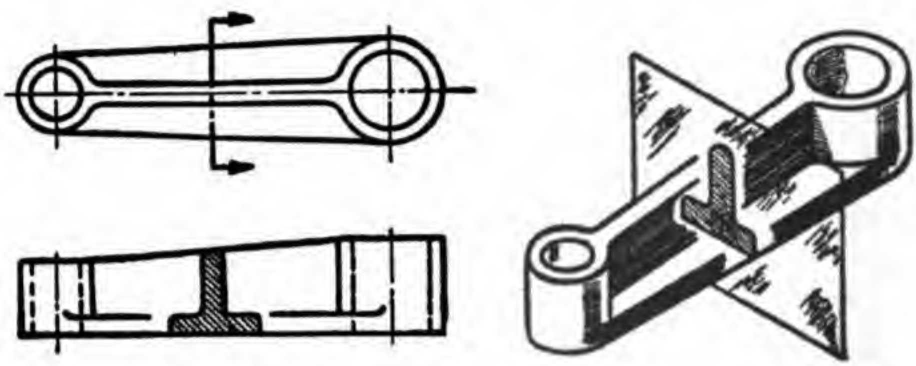


Figure 3–6.—Revolved section.

The draftsman has revolved the sectional view of the rib in figure 3–6 so that you can look at it head-on. Because of this revolving feature this kind of section is called a revolved section.

BROKEN-OUT SECTION

The inner structure of a small area may be shown by peeling back or removing the outside surface. The inside of the counterbored hole is better shown in figure 3–7 because of the BROKEN-OUT SECTION, which makes it possible for you to "look inside."

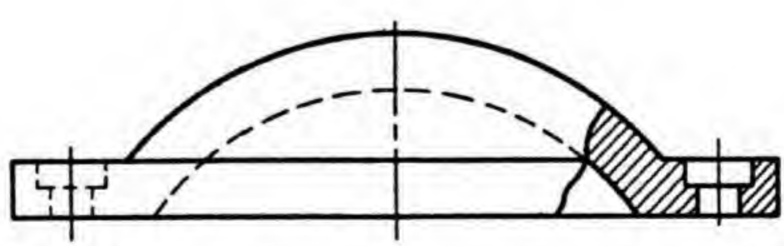


Figure 3–7.—Broken-out section through a counterbored hole.

ALINED SECTION

Look at the front view of the handwheel in figure 3-8. Notice the cutting plane line, AA.

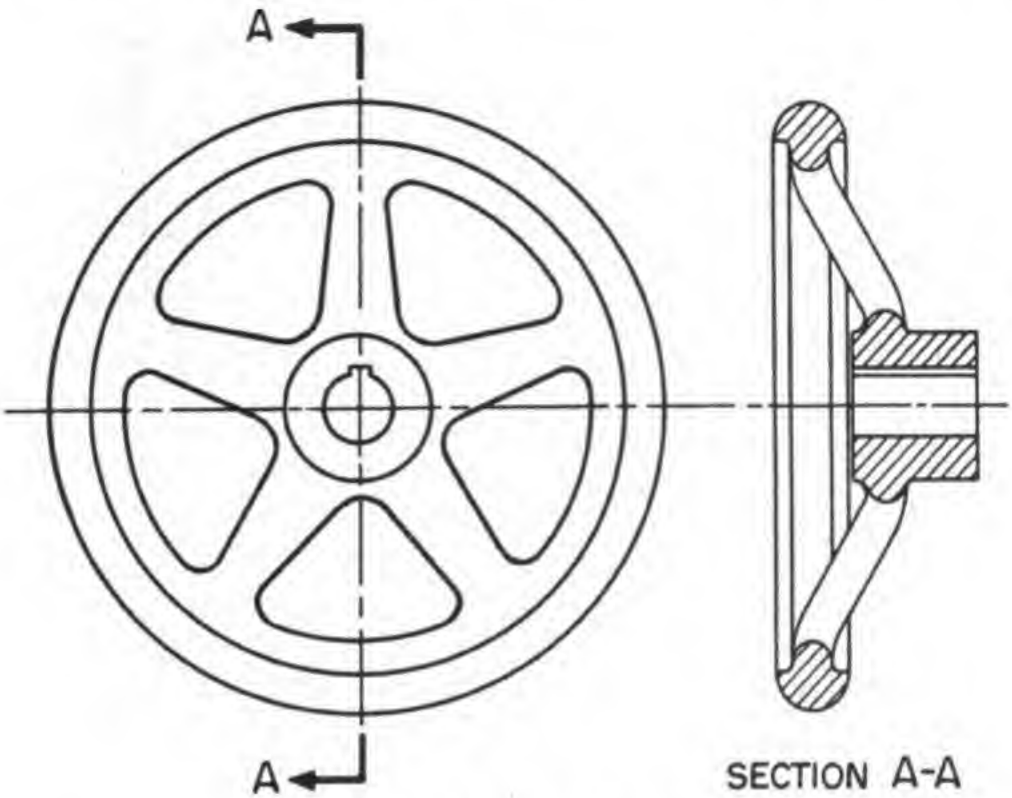


Figure 3-8.—Alined section.

When a true sectional view might be misleading, parts such as ribs or spokes are drawn as if they were rotated into or out of the cutting plane. Notice that the spokes in the section at *A-A* are not sectioned. In some cases, though not in this figure, if the spokes were sectioned the first impression would be that the wheel had a solid web rather than spokes.

CONVENTIONAL BREAKS AND SHAPE SYMBOLS

A long bar or pipe that has a uniform cross section is not always shown in its entire length. By breaking out one or more pieces and moving the ends together, a larger and more readable scale can be used. The true length, of course, is still indicated by the dimensions stated on the blueprint.

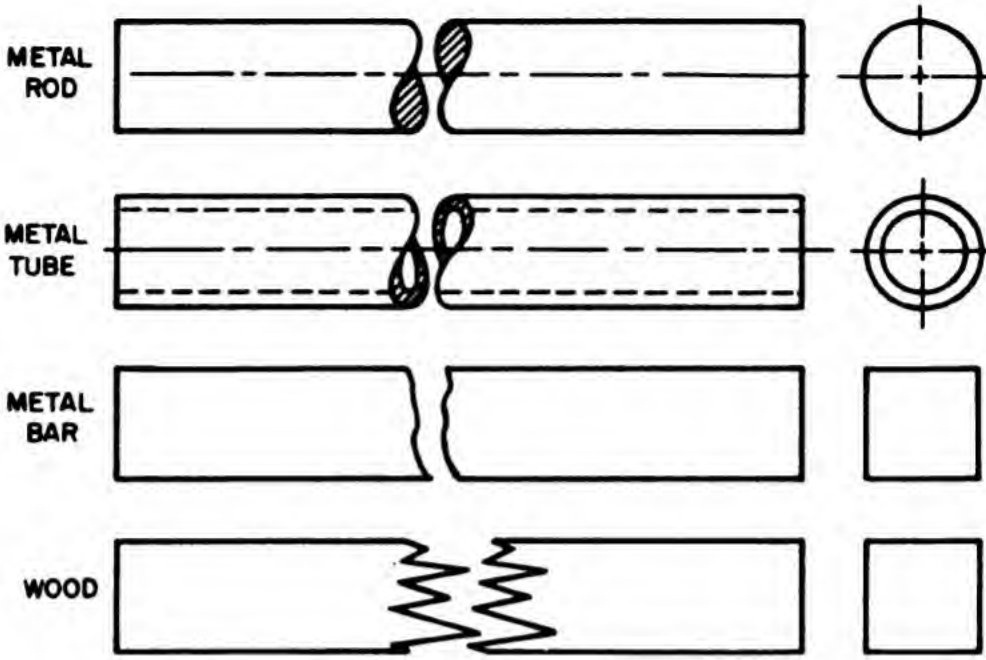


Figure 3–9.—Conventional breaks in special solid shapes.

The draftsman uses an assortment of lines to indicate breaks in showing different shapes and materials. Figure 3–9 shows some of the conventional breaks employed in drawings to indicate special shapes and symbols.

MATERIAL SYMBOLS

The Military Standards of the Department of Defense include certain material symbols for section views. You can see a part of this official code in figure 3–10. It will be well worth your while to learn these material symbols or simplified conventions. They are known as SIMPLIFIED SECTIONING CONVENTIONS and their use is preferred wherever practical.

On nonstandard prints you may also find other special symbols—and even colors—but such special usages will always be explained in the blueprint.

HOW THREADS ARE DRAWN

There are various ways of representing threads. OUTSIDE THREADS are shown in figure 3–11.

On the left in figure 3–11 you see a thread profile in section.

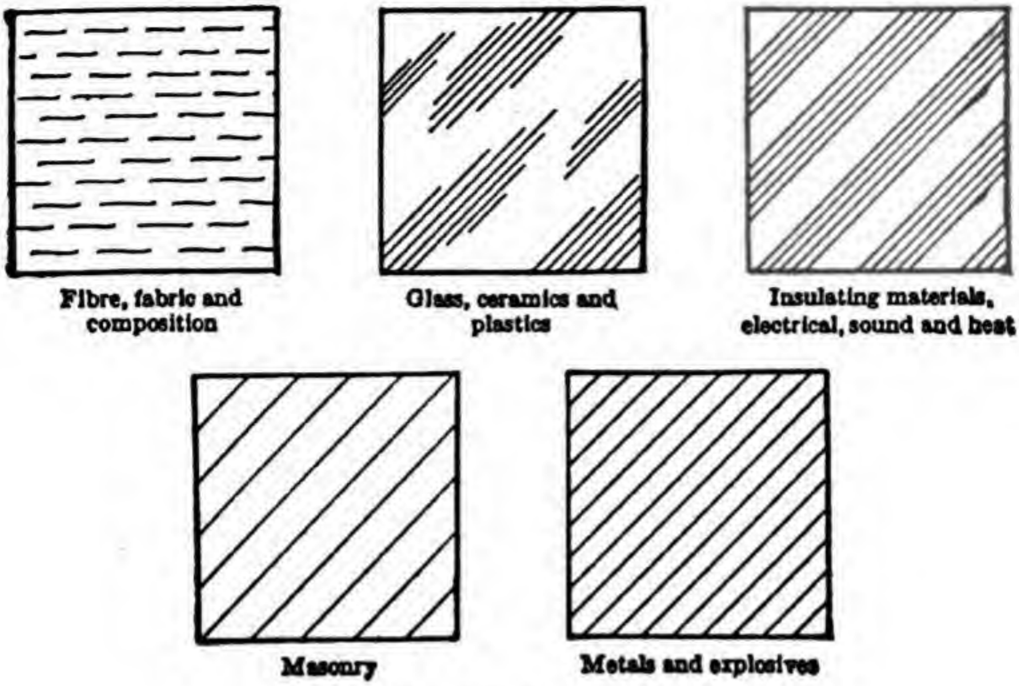


Figure 3-10.—Simplified conventions.

On the right is a common method of showing threads. To save time the draftsman uses symbols that are not drawn to scale. The length of the threaded part is dimensioned, but other necessary information appears in the NOTE, which in this case is ¼–20 NC–2.

The first number of the note, ¼, indicates the nominal size which is the outside diameter. The number after the first dash, 20, shows that there are 20 threads per inch. The letters NC indicate the thread series, National Coarse. The last number, 2, indicates the class of thread and tolerance, commonly called the "fit". If it is a left-hand thread, a dash and the letters LH will follow the class of thread. Threads without the LH are right-hand threads.

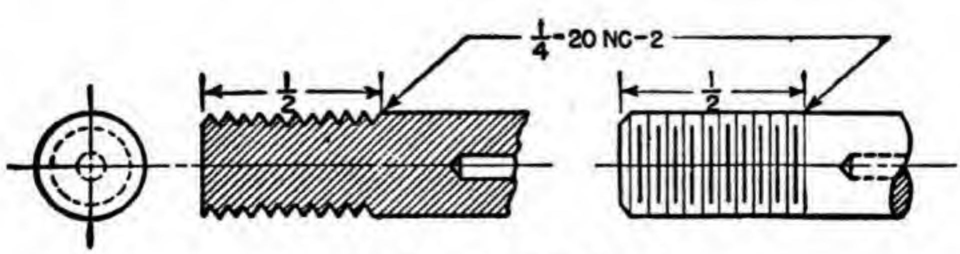


Figure 3-11.—Outside threads.

Specifications necessary for the manufacture of screws include thread diameter, number of threads per inch, thread series, and class of thread. According to thread pitch, the two most widely used screw-thread series are the Unified or National Form Threads, National Coarse, or NC, and National Fine, or NF threads. The NF threads have more threads per inch of screw length than the NC.

Classes of threads are distinguished from each other by the amount of tolerance or tolerance and allowance specified. This was formerly known as "class of fit," a term which will probably remain in use for many years. The new term, "class of thread," was established by the National Bureau of Standards in the 1950 Supplement to Screw-Thread Standards for Federal Services, Handbook H-28 (1944).

Threads are classified as follows:

Class 1. Permits quick and easy assembly of threaded parts where an allowance is required.

Class 2. Applies to the major portion of threaded work in interchangeable manufacture where no allowance is required.

Class 3. Applies to the highest grade of interchangeable screw-thread work and is the same in every particular as class 2 fit except that the tolerances are smaller.

Class 4. Intended for threaded work requiring a fine snug fit, and where a screw driver or wrench may be necessary for assembly. Used only where special conditions require screws having a precision fit.

Class 5. Intended for interchangeable threaded studs and holes which are to be assembled permanently by a turning force.

THREAD FACTORS

Following are definitions of some of the terms commonly used in connection with threads:

Pitch is the distance between corresponding points on two adjacent threads measured parallel to the axis.

Lead is the distance a screw thread advances along the axis in one turn. On a single-thread screw the lead and pitch are identical. On a double-thread screw the lead is twice the

pitch. On a triple-thread screw the lead is three times the pitch.

MAJOR DIAMETER is the largest diameter of the thread of the screw or nut. It will be an O. D. for a screw and an I. D. for a nut.

MINOR DIAMETER is the smallest diameter of the thread of the screw or nut. It will be an O. D. for a screw and an I. D. for a nut.

CREST is the surface of the thread corresponding to the major diameter of the screw and the minor diameter of the nut.

PITCH DIAMETER is the diameter of an imaginary cylinder the surface of which would pass through the threads at such points as to make equal the width of the threads and the width of the spaces cut by the surface of the cylinder.

ROOT of a thread (the bottom of the valley) is the surface of the thread corresponding to the minor diameter of the screw and the major diameter of the nut. Or, the root is the bottom surface joining adjacent sides or flanks of a thread.

DEPTH of a thread is the distance between the crest and the base of the thread measured normal to the axis.

INTERNAL THREADS (fig. 3–12) may be shown by several

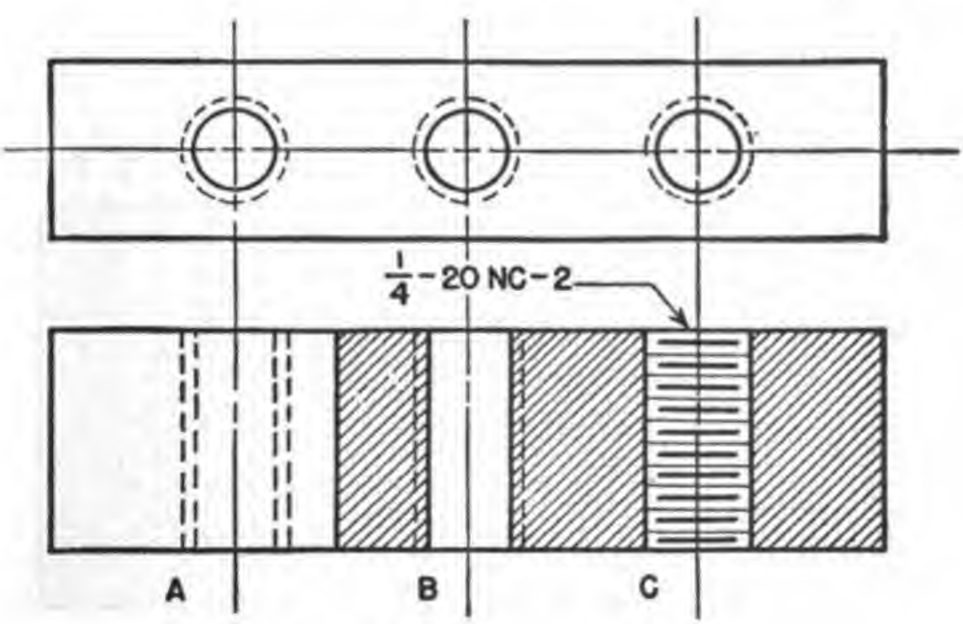


Figure 3–12.—Internal threads.

kinds of symbols. Here again it isn't necessary to draw the threads when an easily drawn symbol will do just as well.

Notice that the threads in figure 3–11 may be screwed into the threaded holes in figure 3–12. How do we know? Because the note on each one tells us that the threads are exactly the same.

Threads may be shown IN SECTION, especially in assembly views. Look at figure 3–13. It shows clearly the relationship of the threaded members.

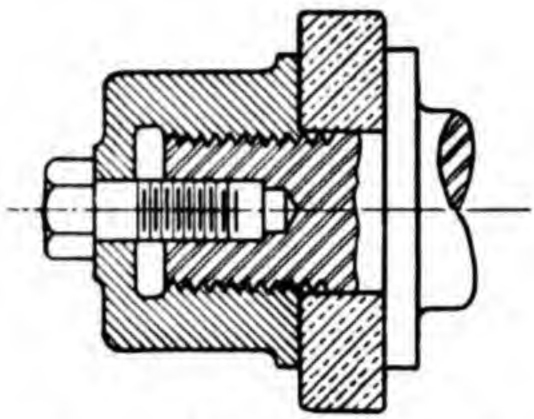


Figure 3–13.—Threaded assembly.

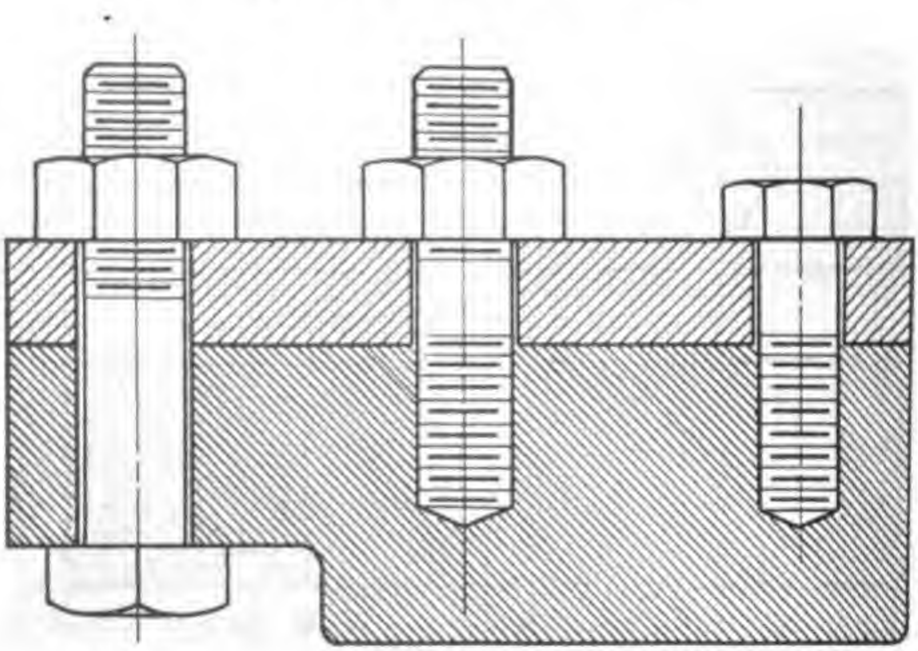


Figure 3–14.—Bolts and studs.

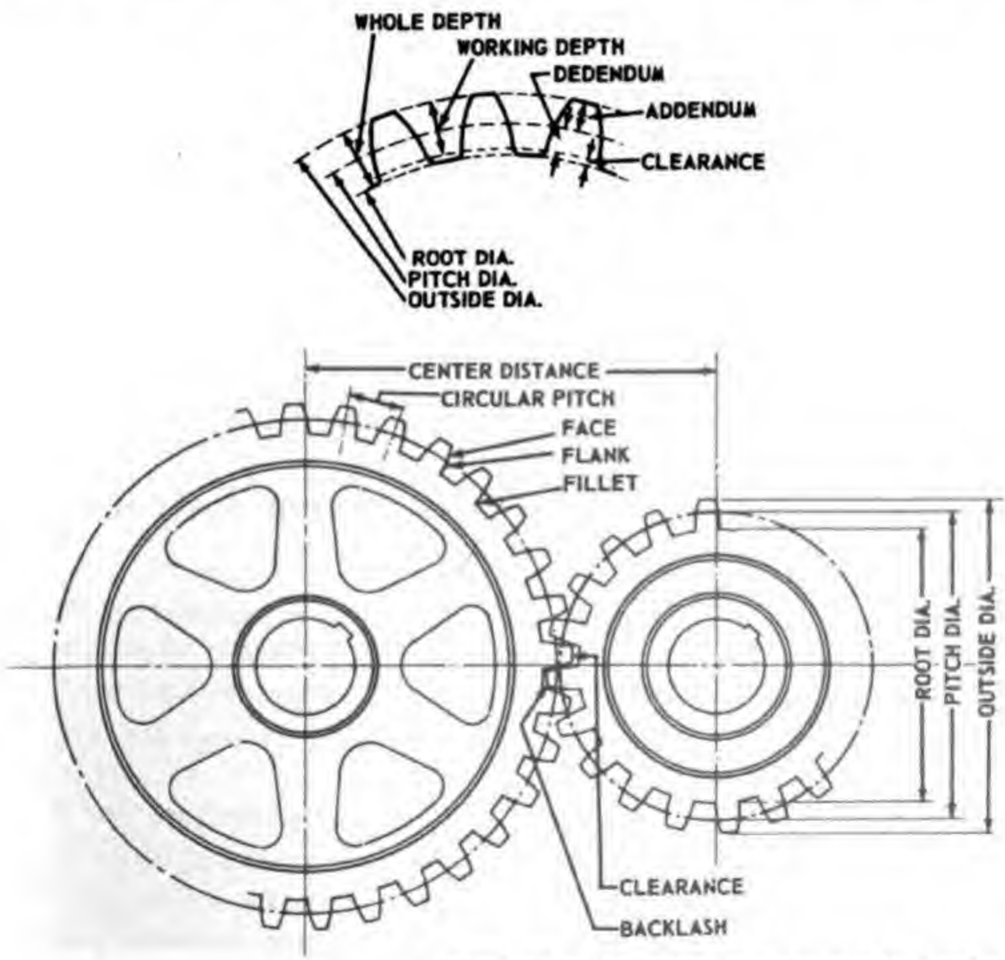
Bolts and studs are indicated on drawings by outlines and symbols, as shown in figure 3–14.

GEARS

Gear teeth generally are not shown on blueprints, except when a few are drawn to indicate the proper dimensions. Figure 3–15 shows how gears may be represented on a mechanical drawing; see the three teeth at the top of the figure.

GEAR NOMENCLATURE

Special terms are used to indicate gear measurements. Some of these terms have been added to figure 3–15 for the purpose of the discussion here, but they would not be so



Courtesy of American Foundrymen's Society

Figure 3–15.—Gear nomenclature.

designated on a blueprint. Instead they would appear as notes giving the appropriate dimensions, for example:

Diametral Pitch 5
Addendum 0.1131
Dedendum 0.0992

Some of the more common terms used with gears are as follows (see fig. 3–15):

FACE WIDTH is the distance across the pitch surface of a gear.

PITCH DIAMETER: imaginary diameter on which gears would roll as cylinders.

DIAMETRAL PITCH: number of teeth per inch of pitch diameter.

PITCH CIRCLE: the circle having the pitch diameter.

CIRCULAR PITCH: distance on the pitch circle between corresponding points of two adjacent teeth.

WHOLE DEPTH OF TOOTH: distance from the outside diameter to the bottom of the tooth.

WORKING DEPTH: greatest depth to which a tooth of one gear extends into the tooth space of another gear.

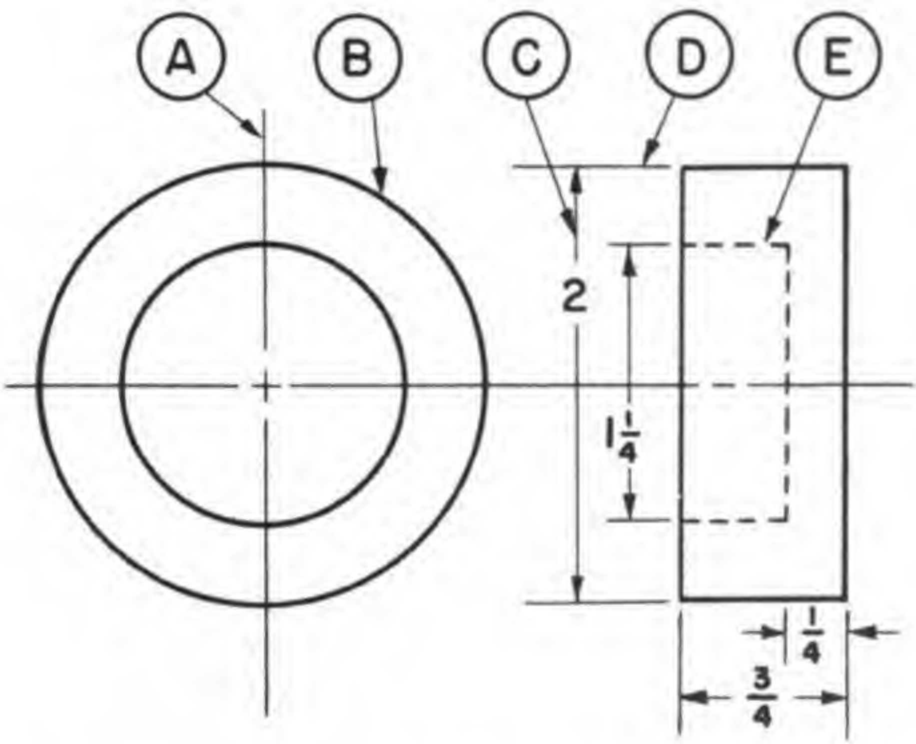
ADDENDUM: radial distance from the pitch circle to the top or crest of the teeth.

DEDENDUM: radial distance from the pitch circle to the bottom or root of the teeth.

CLEARANCE: radial distance from the top of one tooth to the bottom of a tooth mating space.

QUIZ

1. Number your paper from A to E and write down the names of the five lines in the accompanying illustration.



2. What material symbols are often used to indicate metals and explosives, masonry, and insulating materials?
3. What kind of section is shown as a drawing within a drawing?
4. The line running from a note to the indicated position is called what?
5. What, with relation to an object, does a revolved section describe?
6. What do you call a view that lets you "look inside" an object?
7. With what is a sectional view marked on a drawing?
8. In a sectional view, the part that has been sectioned, or section-lined, has been "opened up" by a __________ plane.
9. An offset section is produced by an __________ in the __________.

10. In a half section does the cutting plane expose half or all of the inside of the object?
11. When an offset cutting plane "quarters" a diesel engine piston, for instance, the section would be a __________ section.
12. A broken out section is usually smaller than a half section. Is this correct?
13. What do the four numbers (¼–20 NC–2) indicate in the note that appears with a thread on a drawing? Give the answer in proper order, reading from left to right.
14. How are left-hand threads indicated on a blueprint?
15. How are right-hand threads indicated on a blueprint?
16. What three diameters are there on a blueprint for a spur gear or pinion gear that must be noted carefully when reading the print?

CHAPTER 4

DIMENSIONS

DEGREE OF ACCURACY

If you fail to follow the dimensions on a blueprint, you may make a part that will not give the service for which it is designed, and it may break down, endangering the lives of men and defeating the mission they were sent to accomplish. An error of 5/1000 inch can be as destructive as one quarter inch. In fact, a small error may be even more dangerous because it is not so easily detected. The part may pass inspection—it may even perform satisfactorily for a while. But when it breaks down, it may start a destructive chain reaction, damaging other equipment and perhaps even injuring personnel.

Absolute accuracy is impossible. Even the 6-inch rule with which you measure is not absolutely accurate. Temperature alone can cause variations in it; cold may cause it to be slightly shorter than 6 inches, and heat may make it slightly longer than 6 inches.

Because engineers realize that absolute accuracy is humanly impossible, they figure how much variation is permissible. This leeway is stated on the drawing as $\pm$ a certain amount, as $\pm \frac{1}{8}$, $\pm \frac{1}{64}$, or ± 0.005.

LIMITS AND TOLERANCE

The dimension on a blueprint represents the perfect size and is known as the BASIC DIMENSION. In figure 4–1 it is 3 inches. The limit of error allowed is one-eighth inch. The minimum length is $2\frac{7}{8}$ inches, the maximum length is $3\frac{1}{8}$ inches, and the tolerance is $\frac{1}{4}$ inch and represents the

total permissible variation in its size. Or, tolerance is the difference between the limits of size.

Don't expect to have that much leeway on most work. Woodworking usually requires a limit of $\pm\frac{1}{32}$ inch, sheet metal work $\pm\frac{1}{64}$ inch, and machine parts ± 0.005 inch or less. Many fine mechanisms have limits of error of ± 0.0001 inch, and it is possible in some instances to make parts which are accurate to a few millionths of an inch. You can trust your eyes to measure one sixty-fourth of an inch with a rule, but for closer work use a micrometer or special gage.

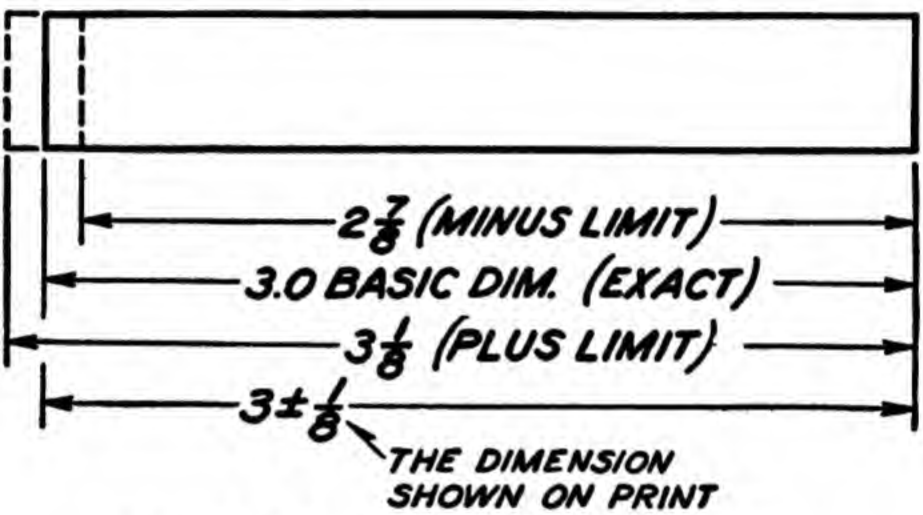


Figure 4–1.—Basic dimension, limits, and tolerance.

As has been stated, the permissible amount of variation, or the difference between the allowable minimum and maximum dimensions (minus limit and plus limit) is known as the TOLERANCE. In figure 4–1 it is one-quarter inch. Here is another example to show you how the system works:

Basic dimension	$2\frac{1}{2}$
Limits	$\pm\frac{1}{64}$
Long limit	$2\frac{33}{64}$
Short limit	$2\frac{31}{64}$
Tolerance	$\frac{2}{64}$ or $\frac{1}{32}$

LIMITS are the extreme permissible dimensions of a part and, stated in either common fractions or decimal fractions, are found in the title block or legend. Angle limits are stated in terms of degrees, as $\pm\frac{1}{2}°$.

When you're working with limits, try to hit the basic dimension, right on the nose. That will help you to stay inside the allowable limits.

ALLOWANCE

The terms "tolerance" and "allowance" are often used interchangeably, but, according to common usage, ALLOWANCE is an INTENTIONAL DIFFERENCE in dimensions prescribed in order to obtain various classes of fits between different parts. It is a minimum clearance (positive allowance) or maximum interference (negative allowance) which is intended between mating parts. CLEARANCE is the total space between an individual pair of mating parts. INTERFERENCE is the total amount of deformation which must be effected in order to force an internal member into a smaller external member. See figure 4–2 for illustrations of clearance and interference.

In ordinary machine construction five classes of fits are commonly used. They are: Class 1, running fit; Class 2,

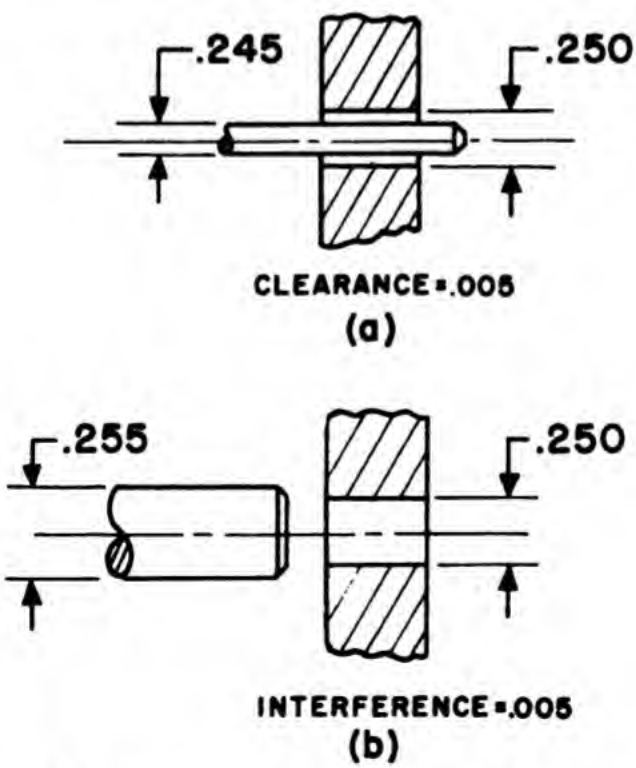


Figure 4–2.—Illustration of clearance and interference.

push fit; Class 3, driving fit; Class 4, forced fit; and Class 5, shrinkage fit.

As the name implies, the running fit, Class 1, is used when the parts must rotate. A push fit, Class 2, is not sufficiently free to rotate. The other classes, 3, 4, and 5, are used when the parts being assembled must be held in fixed positions.

The class of fit should be based primarily on the function of the part. Allowances that are permitted for the several classes of fits will be given in tables contained in standard handbooks. The dimensions given in these tables may sometimes have to be decreased or increased. As an example, for running fits the allowances are increased with the diameter, but may have to be varied according to the length of the bearing surface.

Remember that allowance is the difference in size of mating parts, and that it is necessary for their proper operation. Also keep in mind that the larger the class number, the tighter the fit.

The allowance for a running fit is known as CLEARANCE and is said to be POSITIVE because the hole diameter is greater than the shaft diameter. For classes 2 through 5 this allowance is NEGATIVE and is known as INTERFERENCE. The minimum allowable interference is specified by the dimensions given on the blueprint.

BASIC HOLE ALLOWANCE SYSTEM

The BASIC HOLE ALLOWANCE SYSTEM is a standard method of determining the permissible variations in the size of holes and mating shafts to provide interchangeability of parts. In industry this is a common and standard practice in production manufacturing. A repair ship may get an order for one or two sets of turned parts that must have a certain fit. If the order is one that seldom comes through, probably each set will be made up individually with the required fit. However, these may be parts that are ordered repeatedly over a period of time by many ships. In this case the repair ship would want to set up for the job—on a turret lathe for

instance—and make a short production run, depending on available stowage and probable future demands. The finished parts would then be stowed away and ready for subsequent requests. This is where it pays off to have interchangeable parts, so you will want to know something about the basic hole allowance system.

In that system the hole can be larger than the basic dimension, but it cannot be smaller. The hole limits are plus only. This is known as a PLUS TOLERANCE and is shown with the hole dimension in figure 4–3. The plus tolerance always appears above the minus tolerance. You would refer to the size of this hole, verbally, as "two and a half, plus three, minus nothing" and to a technician that would mean the size information given in figure 4–3 for the hole.

The shaft can be smaller than the basic dimension, but it cannot be larger. The shaft limits are minus only. This is known as a MINUS TOLERANCE and is shown with the shaft dimension in figure 4–3. Again, the minus tolerance always appears below the plus tolerance.

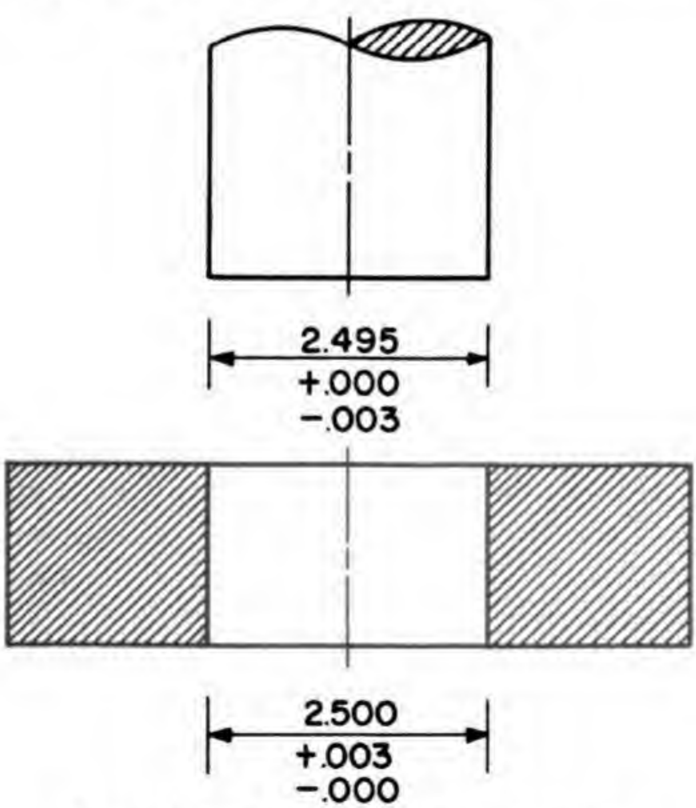


Figure 4–3.—Basic hole allowance system.

If you recall the definition of "clearance" and look again at figure 4–2a, you will see that the tolerances given in figure 4–3 represent clearance. This means that the hole is larger than the shaft. How much larger? Well, referring again to figure 4–3, you notice that the size limits for the hole are actually from 2.500 to 2.503. The size limits for the shaft are actually from 4.495 to 4.492. This means that the hole can be as large as 2.503 but no larger and that the shaft can be as small as 2.492 but no smaller. These size limits—plus and minus tolerances—provide a fit between these mating parts with a clearance of no less than 0.005 inch and no more than 0.011 inch. The 0.005 inch represents the difference between the smallest hole and the largest shaft. The 0.011 inch represents the difference between the largest hole and the smallest shaft. These parts will be interchangeable parts when made in accordance with this basic hole allowance system.

CONTINUOUS DIMENSIONS

For small parts that have few location dimensions, CONTINUOUS, or ACCUMULATIVE, DIMENSIONS are useful.

Look at *a* in figure 4–4. Suppose the limits are $\pm \frac{1}{32}$ inch, which means, of course, that there is a tolerance of one-sixteenth inch. If you cut the stock so that it is one thirty-second inch under size, it will pass inspection. In laying out the holes, you may make a plus error of one thrity-second inch on each hole. You'll have a total error for all five holes of five thirty-seconds. You've joined each dimension to the preceding one in a continuous line, with the result that all errors have accumulated. There is a possible error as great as three-sixteenths inch, all of which will be thrown into the 1-inch dimension making it only thirteen-sixteenths inch. This might make the finished piece unusable due to using continuous dimensioning.

BASELINE DIMENSIONS

You can avoid accumulative errors by using BASELINE, or NONACCUMULATIVE, DIMENSIONS. This method is shown in *b* of figure 4–4.

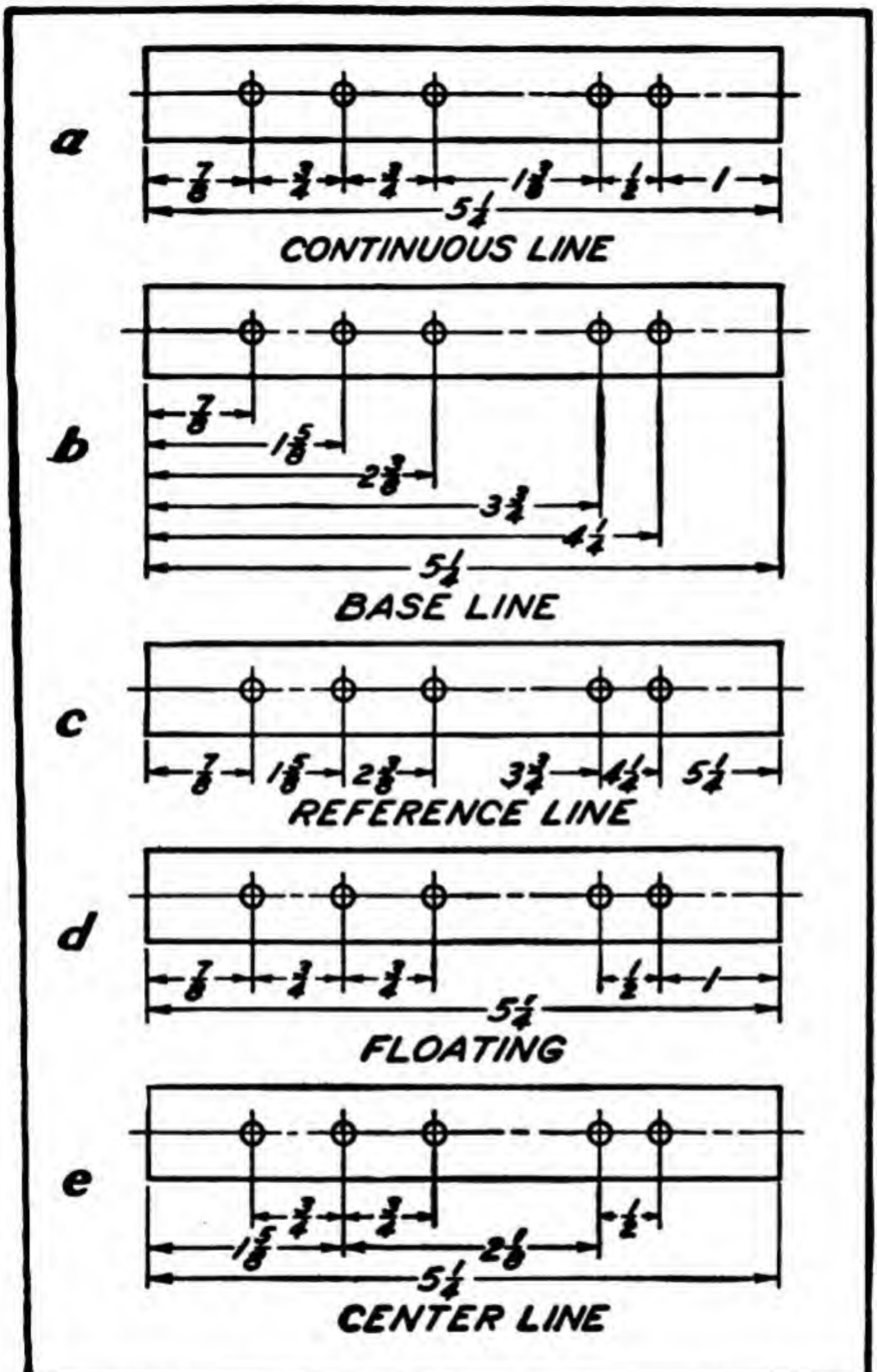


Figure 4–4.—Dimensions at work.

If you use the left end as reference edge, you won't be more than one-sixteenth inch out at most for the distance from any hole to the right end as the hole could be one thirty-second inch too close to the reference edge and the

stock one thirty-second inch too long and still pass inspection. Or the hole could be one thirty-second inch too far from the reference edge and the stock one thirty-second inch too short. This would locate each hole one-sixteenth inch closer to the right end and still pass inspection.

In 4–4*c* is a simplified form of baseline dimensioning. You use the reference line exactly as described for *b*. The aircraft industry prefers this form because it takes less space on a blueprint.

FLOATING DIMENSION

To avoid any error in the last dimension, you can use a floating dimension, which will enable you to control the location of the error.

In *d* of figure 4–4 the middle dimension has been omitted. The draftsman expects errors to fall within that space. Measuring the dimensions on either side of the space from left reference edge and a right reference line will put the errors just where you want them.

CENTERLINE DIMENSION

How are you going to get two parts to fit together exactly, hole for hole? Obviously the chief problem is to control the spacing of each set of holes and the distance between the sets. In figure 4–4*e* you can see how the use of the centerline dimension will help you.

There are three holes in the first set. Notice that the draftsman has given 1⅝ inch as the distance from the reference edge to the centerline of the middle hole. Locate that hole first. Then locate each hole on either side by measuring three-quarters inch from the centerline of the middle hole. That takes care of one set.

From the centerline of the middle hole in the first set, measure off 2⅛ inches. That's where the first hole in the second set goes. Then, using the centerline of the hole you've just located, measure off one-half inch to the last hole.

The same procedure is used on the other, or mating, part, and the holes then should come together.

COST OF LIMITS

The engineer or draftsman not only sets the accuracy necessary for the successful operation of the part, but he also keeps its cost in mind. Limits can cost a lot; hence, you should make a part exactly to its specifications, but no more.

QUIZ

1. a. Why is continuous dimensioning not suitable for parts having many location dimensions?
   b. How does baseline dimensioning avoid the disadvantage of continuous dimensioning?
   c. What is the advantage of measuring inward from the two ends so the one dimension is left "open"?
   d. What do you call the "open" dimension?
2. You are to use the basic hole system to make a hole 6.500 inches into which a shaft is to fit with minimum clearance of 0.0087 inch. Tolerance is 0.0046 inch.
   a. What is the maximum diameter for each part?
   b. What is the maximum allowable clearance between the two parts?
3. How many points should you measure from to secure an accurate layout?
4. The permissible amount of variation is called the ___________.
5. The permissible amount of variation is the mathematical difference between the ___________.
6. Other terms for minimum and maximum dimensions are ________.
7. Machine parts can be and are made as close as what part of an inch?
8. Using a steel rule, you can, with good vision, measure how close?
9. When an arbor press is necessary to press a shaft into a mating hole, the difference in their sizes is called what?
10. What word, in blueprint reading, means the opposite of interference?

CHAPTER 5

TITLE BLOCKS, NUMBERS, AND BILLS OF MATERIAL

THE TITLE BLOCK

The headlines on the blueprint are in the title block or box, which is located in the lower right-hand corner of all drawings prepared according to Military Standards or Joint Army-Navy Standards. It may appear elsewhere on other blueprints, but the lower right-hand corner is the usual place.

The title block contains the drawing number. It also contains all the information required to identify the part or the assembly that the blueprint represents. In approved military blueprints the title block will include the name and address of the government agency preparing the drawing, the title of the drawing, the scale, drafting record, authentication, and date.

If a space has a diagonal or slant line drawn across it, disregard that space, because the diagonal line indicates that the information usually placed in that space is not required on your drawing.

Revision Block

Each drawing shows a revision block located on the right-hand side of the print. Modern practice is to put this space for the recording of changes in the upper right-hand corner, but it may also be placed above the title if desired. All changes to the drawing are noted in this block and are dated and identified by a number or a letter. If, for some reason,

a revision block is not used, a revised drawing may be shown by the addition of a letter to the original number; for example, 103465–26–A.

NUMBERS

Drawing Number

All drawings are identified by a drawing number, which appears in a number block in the lower right-hand corner of the title block. It may be shown in other places also; for example, near the top border line, in the upper right-hand corner, or on the reverse side at both ends so that it will show when a drawing is rolled. Its purpose is to permit quick identification of a blueprint by number. If a blueprint has more than one sheet, and each sheet has the same number, this information is included in the number block indicating the sheet number and the number of sheets in the series.

Reference Numbers and Dash Numbers

Reference numbers that appear in the title block refer you to the numbers of other blueprints. When more than one detail is shown on a drawing, dash numbers are frequently used. Suppose two parts were shown in one detail drawing. Both would have the same drawing number, plus an individual number, as 34105–1 and 34105–2.

In addition to appearing in the title block, the dash numbers may appear on the face of the drawings near the parts they identify. Some commercial prints show the drawing and dash numbers and point with a leader to the part; others use a circle, three-eighths inch in diameter, around the dash number, and carry a leader to the part.

Dash numbers are also frequently used to identify right-hand and left-hand parts.

Many aircraft parts on the left-hand side of an airplane are exactly like the corresponding parts on the right-hand side—in reverse. The left-hand part is always shown in the drawing. The right-hand part is called for in the title block.

Above the title block you'll see a notation such as "159674

LH shown; 159674-1 RH opposite." Both parts carry the same number. But the part called for is distinguished by a dash number. LH means left hand, and RH means right hand. Some companies use odd numbers for left-hand parts and even numbers for right-hand parts.

Zone Numbers

Zone numbers on blueprints are similar to the numbers and letters printed on the borders of a map to help you locate a particular point. To find a point, you mentally draw horizontal and vertical lines from these letters and numerals, and the point where these lines intersect is the area sought.

You'll use practically the same system to help you locate parts, sections, and views on large blueprints (usually assembly drawings). Parts numbered in the title block can be located on the drawing by looking up the numbers in squares along the lower border. Zone numbers read from right to left.

Station Numbers

On large assemblies—airplanes, for example—a numbering system is used to help locate STATIONS on the assembly, such as fuselage frames. When you see "Fuselage Frames—Sta. 187," you know that the frame is 187 inches aft the nose. The measurement is usually taken from the nose or zero station of the airplane, but sometimes it is taken from the firewall.

The same station system is used for wing and stabilizer frames. The measurement is taken from the centerline, or zero station, of the airplane. Station numbers for a typical aircraft are shown in figure 5–1.

SCALE

The scale of the drawing is indicated in one space of the title block. It indicates the size of the drawing as compared with the actual size of the part. The scale is usually stated

as $1'' = 2''$, $1'' = 12''$ etc. It may be indicated as full size, one-half size, one-fourth size, etc.

If the draftsman uses a scale of $1'' = 2''$, the object is shown half as large as its actual size. For a scale of $3'' = 1''$ the object or part is drawn three times its actual size.

Very small parts are enlarged and large objects are reduced in size to show the views clearly. The scale is selected to fit the object being drawn and the space available on the sheet.

Remember: NEVER MEASURE A DRAWING. USE THE DIMENSIONS. Why? Because the draftsman may have made an error which you would measure and repeat. Or, if the print has been reduced in size from the original drawing, reduction errors may have been introduced which you would include by a physical measurement. Or, you might not take the scale of the drawing into consideration. Then, too, paper stretches and shrinks as the humidity changes thus introducing perhaps the greatest source of error in actually taking a measurement by laying a rule on the drawing itself. Play it safe and READ the dimensions on the drawing; they always remain the same.

Graphical scales are often placed on maps and drawings. These scales indicate the number of feet or miles represented by an inch. Oftentimes a fraction is used, as 1/500, meaning that one unit on the map is equal to 500 like units on the ground. A LARGE-SCALE MAP has a scale of 1 in. = 10 ft.; a map with a scale of 1 in. = 1,000 ft., or 1/5000, is termed a SMALL-SCALE MAP.

An architect's scale is divided into fractional parts of an inch, as eighths, sixteenths, thirty-seconds, etc.

An engineer's scale is used for drawing plans and maps. The scale is usually of triangular cross-section and thus provides six different scales on one rule. Some engineers' scales are flat, with both edges beveled, and provide four scales. Surveyors' plans are plotted to a scale of feet to inches. The engineer's scale is divided into parts to an inch, as, for example, 10 parts to an inch. If the scale is 1 in. = 20 ft., the scale in which the inch is divided into 20 parts is used.

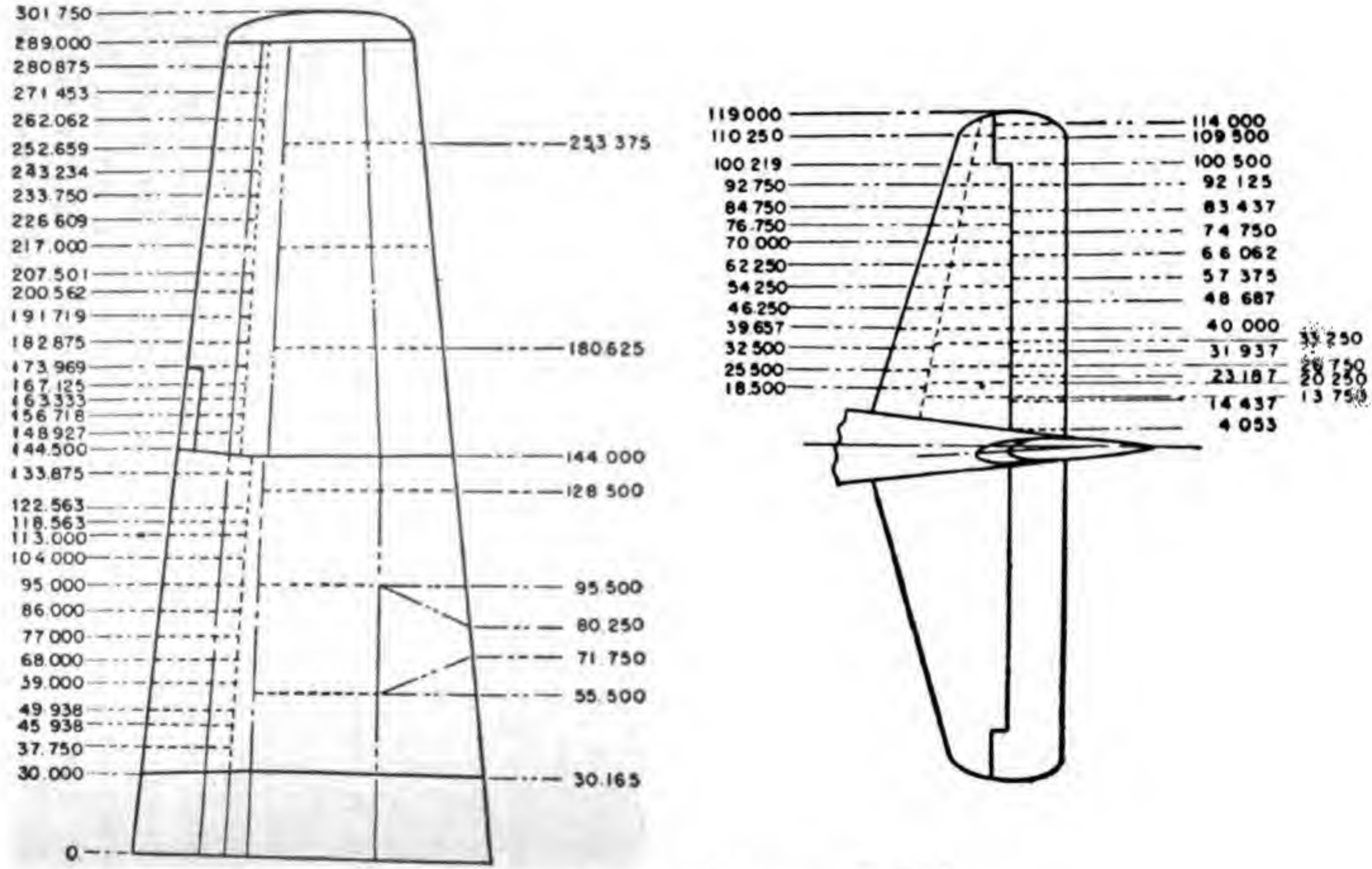


Figure 5-1.—Stations and frames. (Part 1.)

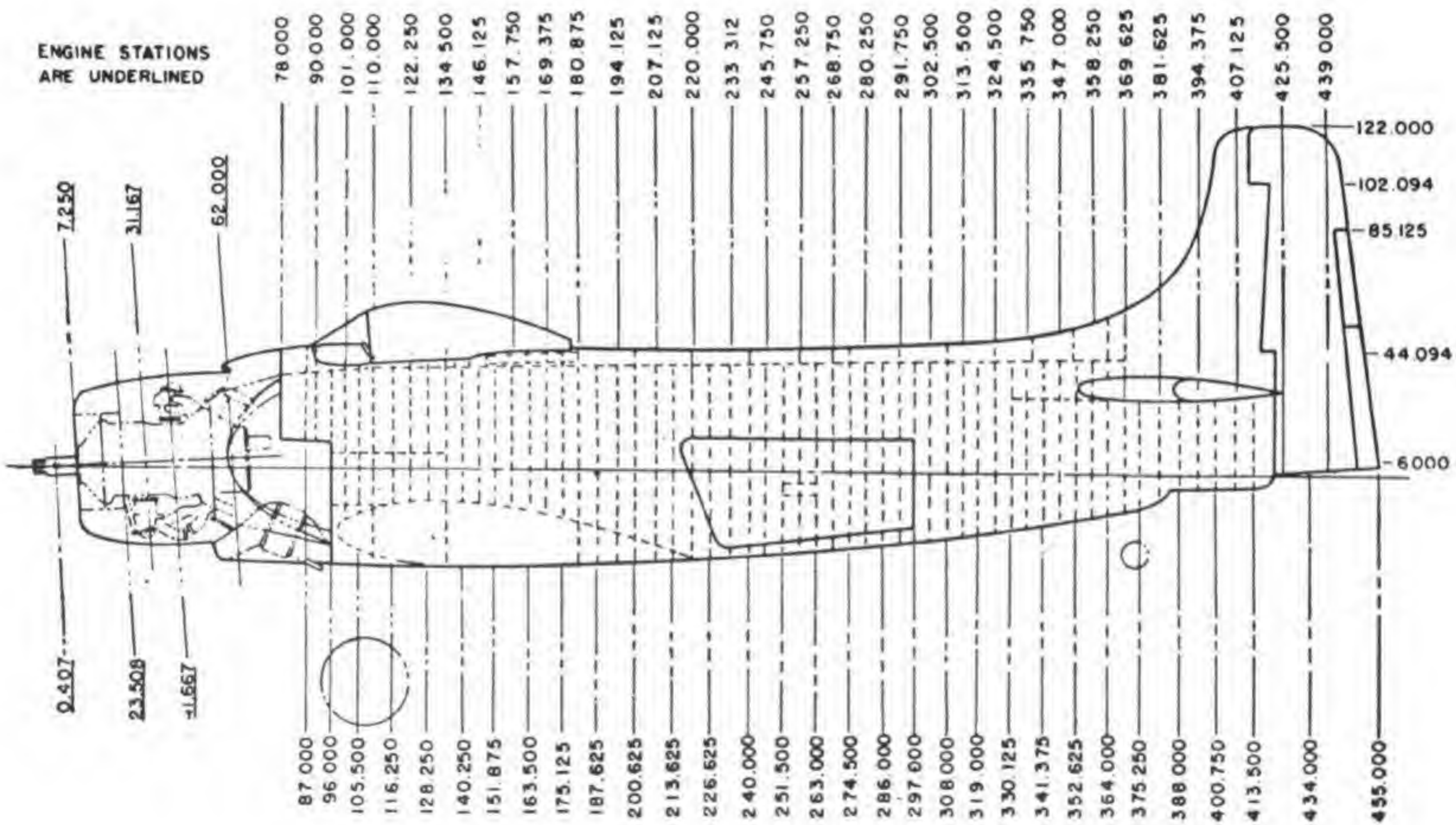


Figure 5-1.—Stations and frames. (Part 2.)

MATERIAL SPECIFICATIONS

Always use the material specified. Never make a substitution unless you have the proper authorization. The material indicated was selected by an engineer because it met the requirements of the job. It's the best material for that particular job. Only an engineer or a man having the authority of an engineer for a particular piece of work can authorize substitutions of material when the kind specified is not available.

Later in this chapter we will say something about the list or bill of materials which further specifies what materials to use.

HEAT TREATMENT

Practically all metals require some form of heat treatment in a manufacturing process. The title block on a blueprint, drawing, or specification lists the type of heat treatment required. Frequently it is necessary to remove the temper from a piece of metal, in order that it may be machined to specifications, after which it must be rehardened. Reference should be made to the heat treatment specifications in the title block, to determine the type required and the point during processing at which heat treatment is to occur.

FINISH MARKS

Finish marks are used to indicate surfaces that must be finished by machining. Machining provides a better surface appearance and provides the fit with closely mated parts. In manufacturing, during the finishing process, the required limits and tolerances must be observed. MACHINED FINISHES should not be confused with finishes of paint, enamel, grease, chromium plating, and similar coatings.

On drawings not prepared according to current governmental specifications, the draftsman may indicate the edges to be finished by placing a small letter *f* on the line representing the finished edge, or he may use the capital letter *V*. When so used, either one is called the FINISH MARK.

Drawings prepared according to government specifica-

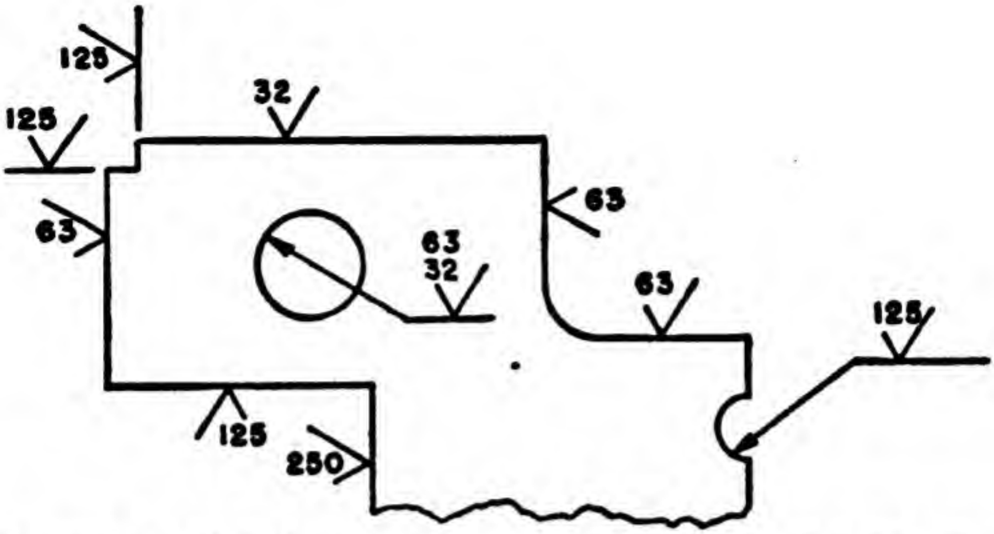


Figure 5–2.—Methods of placing the surface roughness symbol, indicating finish of certain surfaces.

tions require the use of a surface roughness symbol, as shown in figure 5–2. The number inside the surface roughness symbol is the surface roughness number. Waviness and lay numbers may also be used. Full requirements for the use of these symbols may be found in *Military Standard Surface Roughness, Waviness, and Lay* (MIL–STD–10, 2 August 1949).

BILL OF MATERIAL

A special box on the drawing may contain a list of the pieces of stock necessary to make a part or an assembly of several parts. It's called a bill of material and tells the kind of stock, the size, and the specifications.

The bill of material for an assembly drawing often has a list of standard parts. Many commonly used items, such as machine bolts, screws, turnbuckles, rivets, pipe fittings, and valves, have been standardized by the Army, Navy, and Air Force. Each item has a number with AN in front of it. A wing nut, for example, has an Army-Navy specification of AN 350; a flathead sheet-metal screw is listed as AN 531.

INFORMATION ON SPECIFICATIONS

An *Index of Navy Department Specifications* is published quarterly by the Bureau of Supplies and Accounts. It con-

tains bureau interim specifications and joint Army-Navy, Navy, and Federal specifications that are used by the Navy.

Navy Department specifications are approved by all of the interested bureaus and administered by the Navy Department Specifications Board. Such specifications are identified by standard Navy Department specification numbers, which are made up of the standard stock class number, the first letter of the material, and a serial number. For example, Navy Department Specification Number 46–R7, covering oxyacetylene (gas) aluminum A1–2 welding rod, may be broken down as follows:

N:46–R–7, Class A

Navy Department Specification Number

Standard Stock Class Number

First letter of the material (Rod)

Serial number

A particular class of the group covered by specification number (Aluminum, A1–2) (99.5% pure)

In addition to the information that may be had from the specifications, you can find out whatever else you need to know about any general stores item by checking the *Catalog of Navy Material*, General Stores Section.

Some specifications may be followed by "(INT)." These are BUREAU INTERIM (INT) SPECIFICATIONS, and they cover immediate purchase requirements of one of the bureaus. Their use is optional with bureaus other than the sponsoring bureau. Many of these specifications are later adopted by the Navy Department and become specifications required for all bureaus.

JOINT ARMY AND NAVY (JAN or MIL) SPECIFICATIONS

are those that have been developed and adopted for use by the Department of Defense. They are identified by "JAN" or "MIL" preceding the first letter of the material and a serial number.

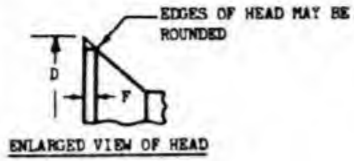
General Specifications for Inspection of Material set forth the requirements to which Navy contractors must conform.

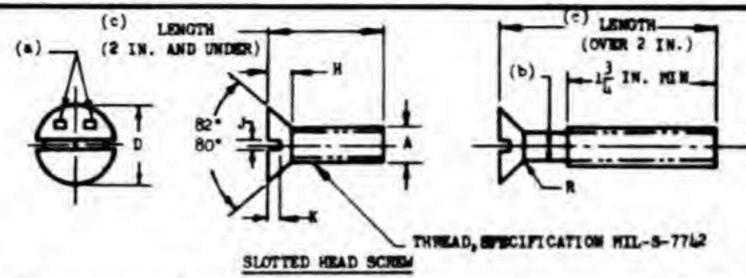
Federal Specifications cover the characteristics of material and supplies used jointly by the Navy with other government departments. All Federal Specifications used by the Navy Department are listed in the *Index of Navy Department Specifications.*

Original issues of Army-Navy Aeronautical Specifications (ANA) are indicated by numbers, simplified for aeronautical use; for example, AN-P-33. Amendments to specifications are printed on green paper, and each succeeding amendment contains all valid requirements of the preceding amendment. Amendments are shown in the *Index* by adding "-1," "-2," etc., to the original number. For example: AN-P-32-2—Second amendment to specification. Revised specifications supersede previous issues of the specifications, together with all amendments. Revisions are shown in the *Index* by adding "a," "b," etc., to the original number; for example, AN-P-33 b——Second revision to specification.

Two types of Army-Navy Drawings (AN, AND) are issued: Standard Drawings, numbered from AN 1 through AN 9999, are used to describe standard parts or assemblies; Design Standard Drawings, numbered beginning at AND 10000, are used to describe design information only. For example: AN 6220—ANA Standard Drawing; AND 10202—ANA Design Standard Drawing.

Revised drawings are identified by numbers in a circle, followed by a date on the right side of the drawings, thus: "② 4-26-46." All specific changes are identified on the drawings by the same circled numbers; thus: "②." Revisions are shown in the *Index* by adding "#1," "#2," etc., to the original number. For example: AN 6220 #2——Second revision to a drawing.





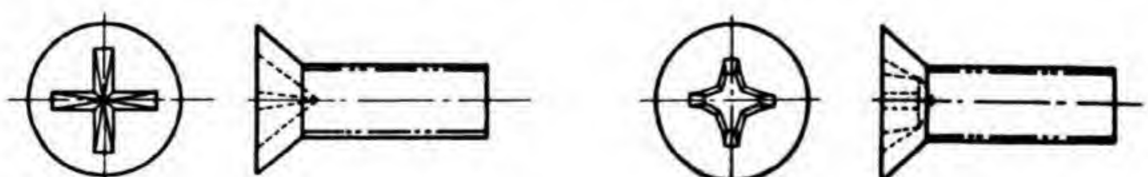
SIZE	A DIA	D DIA			F	H		J		K		R RAD
	MAX	MAX SHARP	MIN SHARP	ABSOLUTE MIN WITH MAX F	MAX	MAX	MIN	MAX	MIN	MAX	MIN	MAX
NO. 0-80 NF-2A	.060	.119	.105	.101	.011	.035	.026	.023	.016	.015	.010	.025
NO. 1-72 NF-2A	.073	.146	.130	.126	.013	.043	.033	.026	.019	.019	.012	.030
NO. 2-64 NF-2A	.086	.172	.156	.150	.014	.051	.040	.031	.023	.023	.015	.030
NO. 3-56 NF-2A	.099	.199	.181	.175	.015	.059	.048	.035	.027	.027	.017	.035
NO. 4-48 NF-2A	.112	.225	.207	.200	.016	.067	.055	.039	.031	.030	.020	.040
NO. 5-44 NF-2A	.125	.252	.232	.225	.018	.075	.062	.043	.035	.034	.022	.045
NO. 6-40 NF-2A	.138	.279	.257	.249	.019	.083	.069	.048	.039	.038	.024	.050
NO. 8-36 NF-2A	.164	.332	.308	.300	.022	.100	.084	.054	.045	.045	.029	.055
NO. 10-32 NF-2A	.190	.385	.359	.348	.025	.116	.098	.060	.050	.053	.034	.060
1/4-28 UNF-2A	.250	.507	.477	.462	.031	.153	.131	.075	.064	.070	.046	.070

(a) MARKING FOR CORROSION RESISTANT STEEL SCREWS. ONLY ONE VISIBLE DASH NECESSARY AFTER SLOTTING OPERATION. POSITION OPTIONAL. NO MARKING REQUIRED ON HEADS OF SIZE NUMBER 4 AND SMALLER SCREWS.

(b) THE DIAMETER OF THE UNTHREADED PORTION OF THE SCREWS SHALL NOT BE LESS THAN THE MINIMUM PITCH DIAMETER NOR MORE THAN THE MAXIMUM MAJOR DIAMETER OF THE THREAD.

(c) FOR MACHINE SCREWS 2 INCHES LONG AND SHORTER, THE COMPLETE THREADS SHALL EXTEND TO WITHIN TWO THREADS OF THE BEARING SURFACE OF THE HEAD OR CLOSER IF PRACTICABLE. SCREWS OF LONGER LENGTH SHALL HAVE A MINIMUM COMPLETE THREAD LENGTH OF 1-3/4 INCHES.

(d) SCREWS DESIGNATED BY (d) TO HAVE UNDERCUT HEADS. (SEE SHEET 2.) OTHER SCREWS TO HAVE REGULAR HEADS.



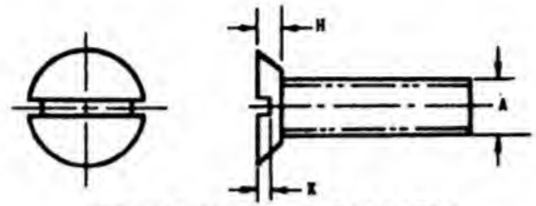
RECESSED HEAD SCREW

THIS TYPE C: RECESS CONSISTS OF TWO INTERSECTING SLOTS WITH PARALLEL SIDES CONVERGING TO A SHARP APEX AT BOTTOM OF RECESS.

RECESSED HEAD SCREW

THIS TYPE OF RECESS HAS A LARGE CENTER OPENING, TAPERED WINGS, AND BLUNT BOTTOM, WITH ALL EDGES RELIEVED OR ROUNDED.

DIMENSIONING AND GAGING OF THE ABOVE TYPES OF RECESSES SHALL BE IN ACCORDANCE WITH THE 1950 SUPPLEMENT TO HANDBOOK H-28 SCREW THREADS FOR FEDERAL SERVICES 1944.



UNDERCUT DIMENSIONS, SLOTTED HEAD SCREWS

SIZE	A DIA	H		K	
	MAX	MAX	MIN	MAX	MIN
NO. 0-80 NF-2A	.060	.025	.018	.015	.010
NO. 1-72 NF-2A	.073	.030	.023	.019	.012
NO. 2-64 NF-2A	.086	.036	.028	.022	.015
NO. 3-56 NF-2A	.099	.041	.034	.025	.017
NO. 4-48 NF-2A	.112	.047	.039	.028	.020
NO. 5-44 NF-2A	.125	.053	.043	.031	.022
NO. 6-40 NF-2A	.138	.058	.048	.035	.024
NO. 8-36 NF-2A	.164	.070	.059	.040	.029
NO. 10-32 NF-2A	.190	.081	.069	.047	.034
1/4-28 UNF-2A	.250	.107	.092	.061	.046

(2) SHEET 2 ADDED.

(2) ENTIRE DRAWING REVISED.

APPROVED 17 May 43 REVISED (1) 15 Jun 50 (2) 21 Feb 52

PROCUREMENT SPECIFICATION	AIR FORCE-NAVY AERONAUTICAL STANDARD	AN510
FF-S-91	SCREW-MACHINE, FLAT HEAD, 82 DEGREE, FINE THREAD	SHEET 1 OF 2

STANDARD ISSUES OF AN510 AND USAF DRAWINGS 42B4937, 42B5702.

Figure 5-3.

A typical AN Standard Drawing of a machine screw is shown in figure 5–3.

The Navy Department Acceptable List is a publication which lists items (made by various manufacturers) that meet the specifications and standards established by the Navy Department.

Commercial trade names or brand names are also used to specify items of material, but they should not be used alone. When you specify material to be ordered or supplied, use all the designations, you can. Give the Navy Department specification number, the size, shape, content, and use of each item.

It's particularly important that you indicate the USE for which the item is intended. Sometimes certain items are out of stock and cannot be supplied immediately. If you state the intended use, the source of supply may be able to furnish a satisfactory substitute to meet the specifications.

USAGE BLOCK

A usage block may be used to identify by their drawing numbers the larger units of which the detail part or subassembly shown on the drawing forms a component. This block is usually near the title block, or it may form a part of the list of material block. Figure 5–4 shows this block in two parts. The solid lines form the basic block and the dash lines indicate quantity columns which may be added when required.

NEXT ASS'Y.	USED ON	NEXT ASS'Y	FINAL ASS'Y
APPLICATION		QUANTITY REQ.	

Figure 5–4.—Usage block.

QUIZ

1. Why is a number stamped, cast, or stenciled on each part of a machine or engine?
2. a. What would these symbols in a blueprint's title block tell you?
   Ring—Fuselage—Sta. 209½
   b. Explain how zone numbers could help you if you were trying to find a view of this fuselage ring on a large assembly blueprint.
3. Where on the blueprint can you always find overall dimensions of the part you are to make?
4. How and where is a change from original design usually designated on blueprints?
5. The scale of a drawing always indicates what?
6. If a drawing is scaled to $1'' = 1' - 0''$, what is the relative size of the drawing compared to the work?
7. Why make drawings to a scale?
8. What errors are you possibly including when you measure a dimension on a blueprint?
9. What is the name of the symbol which tells the craftsman what he is expected to do regarding the "texture" or quality of the various surfaces of a machine part he is making?
10. How do you find out, from a detail print, where the piece you are making will eventually be used?

CHAPTER 6

TECHNICAL SKETCHING

From chapters 2 through 5 of this Navy Training Course you have learned some basic information about blueprints. This information applies to sketches as well as to the mechanical drawings from which blueprints are made. There is no Military Standard for technical sketching. What information is either included on a sketch or omitted is left up to the man who makes the sketch. He will include as much information as he feels necessary to serve the purpose for which he made the sketch. However, whatever information, such as dimensions or notes, that does appear should conform to the *Military Standard for General Drawing Practice*. Since every man in the Navy at some time or other has to read technical sketches in the absence of drawings his task will be simplified if the sketches follow these Military Standards.

As has been stated, mechanical drawings are made with mechanical aids such as a pencil compass, triangles, T-square, and rule. A sketch is usually thought of as being made free hand, although in practice it may be made on squared paper or with the help of a rule and pencil compass.

Usually a sketch is made from an object, but it can also be an "idea" sketch of something you are thinking about, or a combination of both. It can be made with perspective, so that it actually looks like the object, or it can be an orthographic sketch of the object with three different views, usually front, side, and top. It can be either an assembly sketch or a detail sketch. An assembly sketch, as the name implies, will show two or more parts fastened together which may then be a complete unit. A detail sketch will show, in detail, one single part of an assembly.

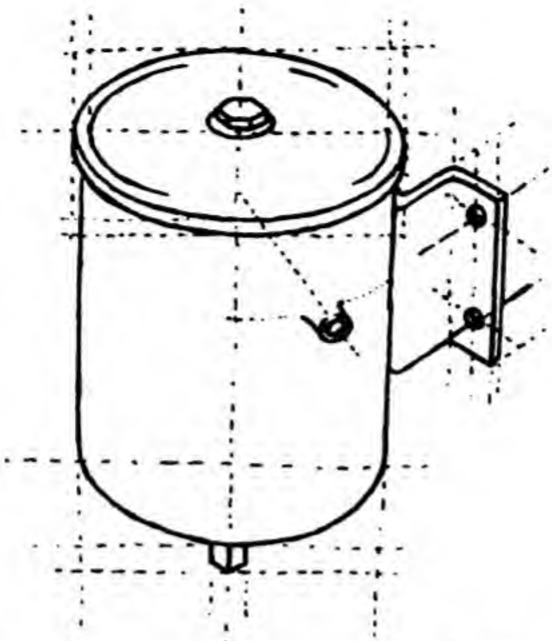


Figure 6-1.—Perspective assembly sketch of an oil filter.

Following are four examples:

1. A perspective assembly sketch of an oil filter, like the one on your car, is shown in figure 6-1. It has been made free hand without the use of instruments and looks just like an oil filter. If a man talked about the oil filter "he had in

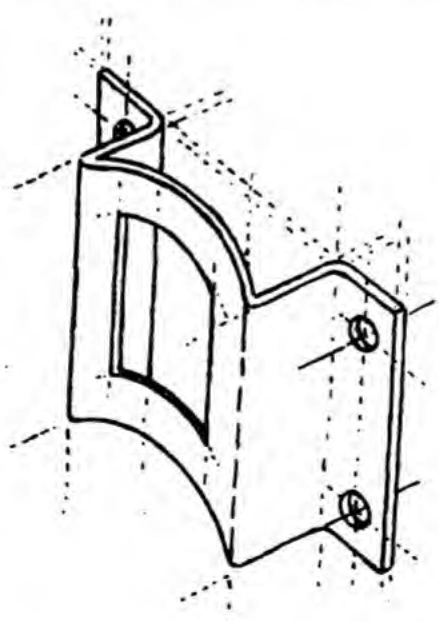


Figure 6-2.—Perspective detail sketch of oil filter bracket.

mind," and handed you this sketch, you would know immediately what he was thinking about.

2. A perspective detail sketch of the bracket which supports the oil filter. You will immediately notice the curved part of the bracket that fits the round body of the filter. A perspective detail sketch looks exactly like the part it represents. See figure 6–2.

3. An orthographic assembly sketch of the oil filter. In each of the three views the oil filter appears completely assembled with the cover in place and the bracket secured to the body. See figure 6–3.

4. An orthographic detail sketch of the oil filter bracket is shown in figure 6–4. It is a detail sketch because it shows only one part of the oil filter, or the oil filter assembly, as it

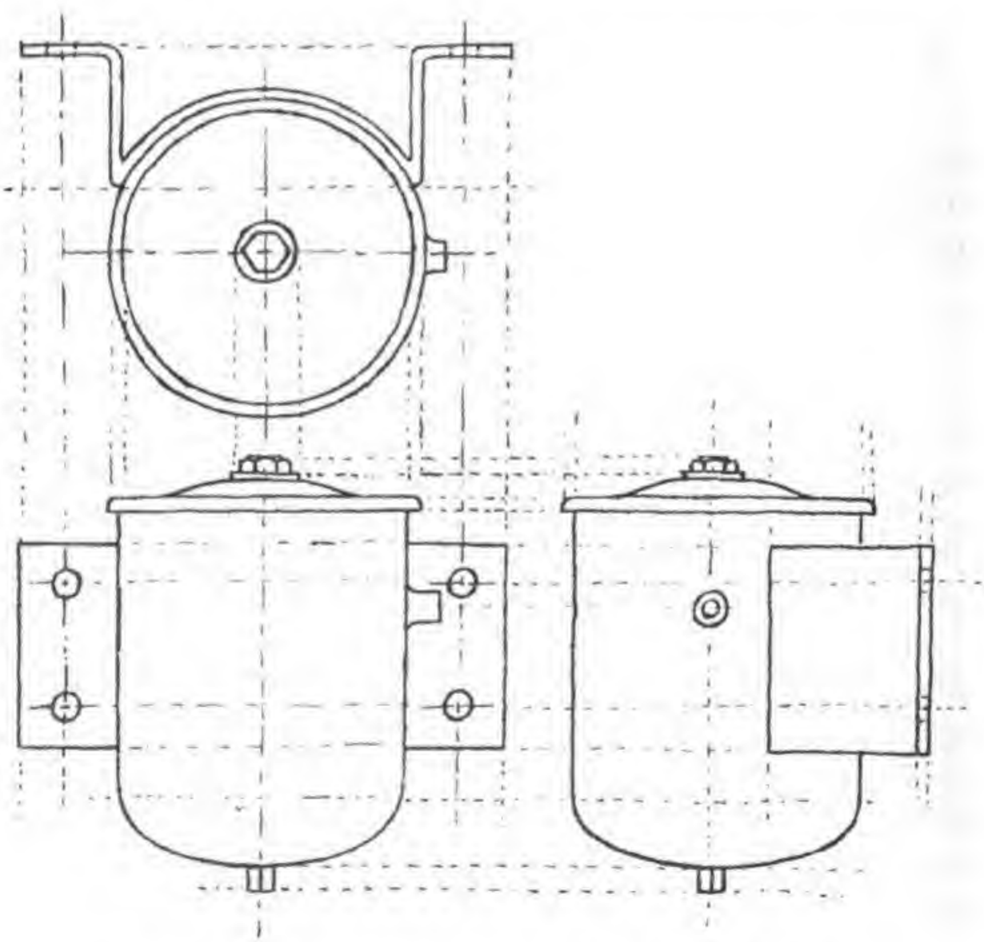


Figure 6–3.—Orthographic assembly sketch of an oil filter.

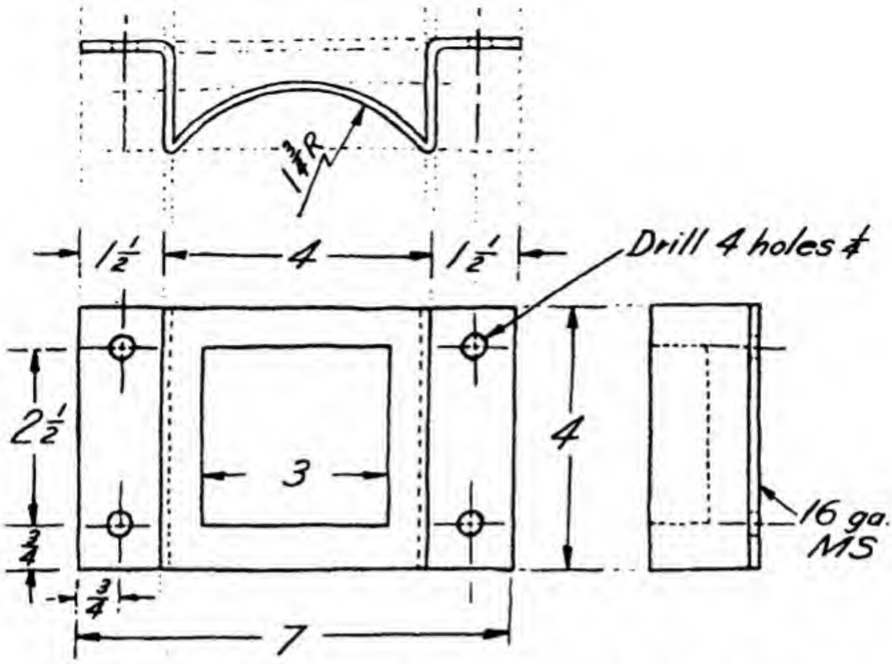


Figure 6–4.—Orthographic detail sketch of oil filter bracket.

might be called. The other two parts, the cover and the body, would appear in two more detail sketches. All three sketches might be made on the same sheet of paper. Notice that this sketch includes dimensions and other information and that it conforms to the *Military Standards for General Drawing Practice.* Complete information is included on this sketch to enable a Metalsmith to make such a bracket which, when finished, would exactly fit the body of the oil filter. That is one purpose of a technical sketch—to enable you to make a part that will fit one or more other parts which together make what is called the assembly, or complete unit.

You have noticed that, in figures 6–1, 6–2, and 6–3, no dimensions are given. There is no reason why they couldn't be. If they were, they would be added, in figures 6–1 and 6–2, with dimension lines along the lines of the perspective. In figure 6–3, as in figure 6–4, the dimension lines would be either vertical or horizontal lines.

A complete set of technical sketches for the oil filter would consist of an assembly sketch showing the entire filter, assembled and ready to attach to the engine, and three detail sketches. The detail sketches would show the body of the

filter in one, the bracket in another, and the cover in still another, each with enough information to enable you to make the items which, when assembled, would be the complete oil filter. So as not to complicate this explanation, certain parts, such as the cover hold-down screw and internal spring and standpipe of the oil filter, have been omitted. They would ordinarily appear on detail sketches or, if purchased as standard items, be shown and so indicated.

TECHNICAL SKETCHING TOOLS

Some of the value in technical sketching ability, in addition to the fact that it is an excellent way to present your ideas to someone else, lies in the fact that so few tools are necessary. If you have a stub of a soft pencil and a scrap of paper handy, you are ready to go. However, a pencil long enough to permit a relaxed but stable grip will improve your sketching. For most sketchings you hold the pencil exactly as you do when writing. If you are sketching a circle it may be easier to do so with the pencil below your hand and held against your four fingers with your thumb.

When making erasures, the eraser at the end of some pencils is, of course, handy and satisfactory for limited use. The soft end of a pencil-and-ink eraser is better, but an art-gum eraser will last longer and do a cleaner job of removing pencil lines from paper.

If you should use a pencil compass, the inexpensive kind costing about a quarter at stationery stores is all you need. A rule of any one of several kinds or sizes can be used as a straight edge. As your ability to sketch improves, you may find that the compass and straight edge can be used less and less until they are no longer needed to produce neat and effective sketches quickly. This is the ideal situation which some men reach before others.

Just as preparing sketches with instruments takes unnecessary time, the use of cross-section paper saves time when this paper is available. It is especially useful when sketching to scale and is usually ruled into one-inch squares. These squares are then subdivided into one-eighth or one-

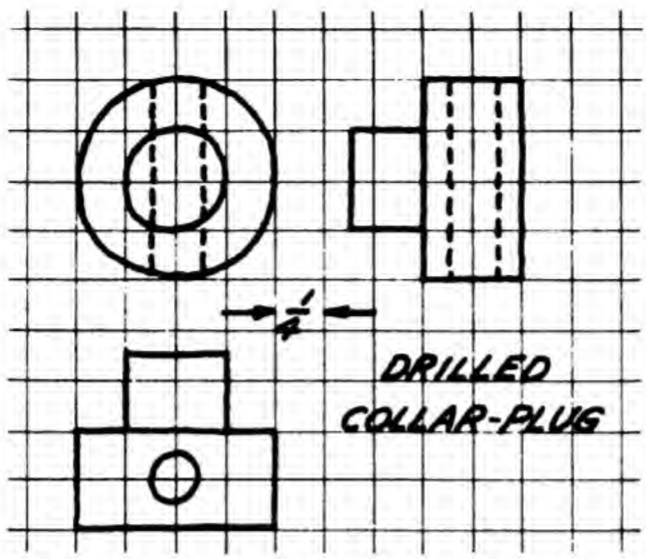


Figure 6–5.—Cross-section paper saves time.

tenth inch squares. Notice that the person who made the sketch in figure 6–5 has indicated that each square represents one-fourth inch.

A specially ruled isometric paper, shown in figure 6–6, is used to make isometric and oblique sketches which are similar to perspectives but whose pairs of lines are parallel. This same ruling is helpful in making the other shapes shown in figure 6–6 and is often a great aid in developing ability to sketch well.

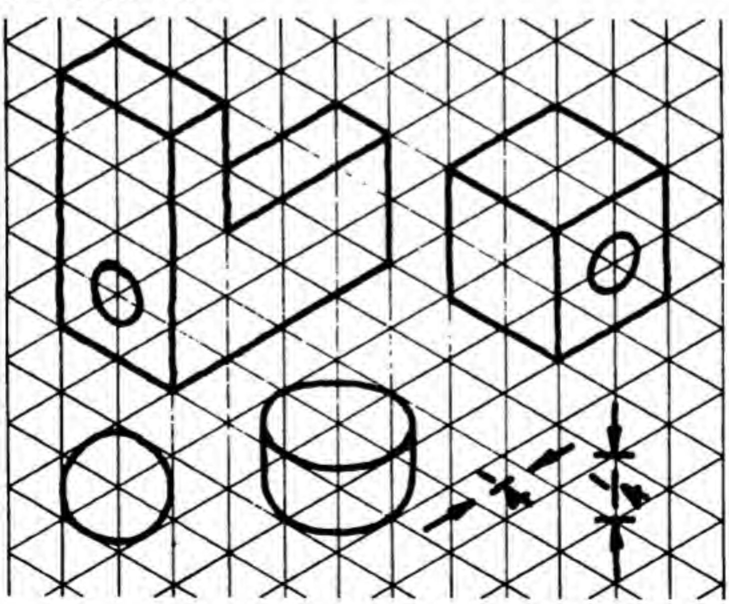


Figure 6–6.—Specially ruled isometric paper.

LINE CHARACTERISTICS AND CONVENTIONS

Figure 3–2 is reproduced from the *Military Standards for General Drawing Practice* (JAN–STD–1, 13 May 1948) which is the latest available at this time. Joint Army-Navy Standards, written JAN-STD, are being superseded by Military Standards, written MIL-STD, which is the term you will find used as standards are changed and brought up to date. The new date will of course appear with the new MIL-STD which supersedes an older JAN-STD. In referring to figure 3–2, notice that lines are classified into four weights: thin, medium, thick, and extra thick. You will want to follow this general idea in your sketches as well as employ the proper way to make the different lines listed at the left in the figure. Remember that a centerline is always a thin line, an outline or visible line is always a thick line, and so forth. Also, the lines which you will sketch will not be as perfect as those in the figure or as they would be if you had made them in a mechanical drawing. Use the figure only as a guide and try to approach it for quality.

LINES

Following are suggestions for sketching lines, but they are only suggestions made to help you get a good start. You may find one or more of them awkward for you to use. If this is the case, try some other way until you find the one which best suits your own abilities. If you can successfully draw the lines shown without moving the paper, that may be a time saver. However, you may also find that you can do your best work by sketching from bottom to top, or left to right, or lower left to upper right. In that case you might actually save time and do better sketching by rotating the paper to suit yourself, and there is no objection to so doing if it is helpful to you.

Holding the pencil from three quarters to an inch from the point so that you can see what you are doing, strive for a free and easy arm movement rather than a cramped finger and wrist movement. As shown in several of the following figures, one way to sketch lines is to locate each end

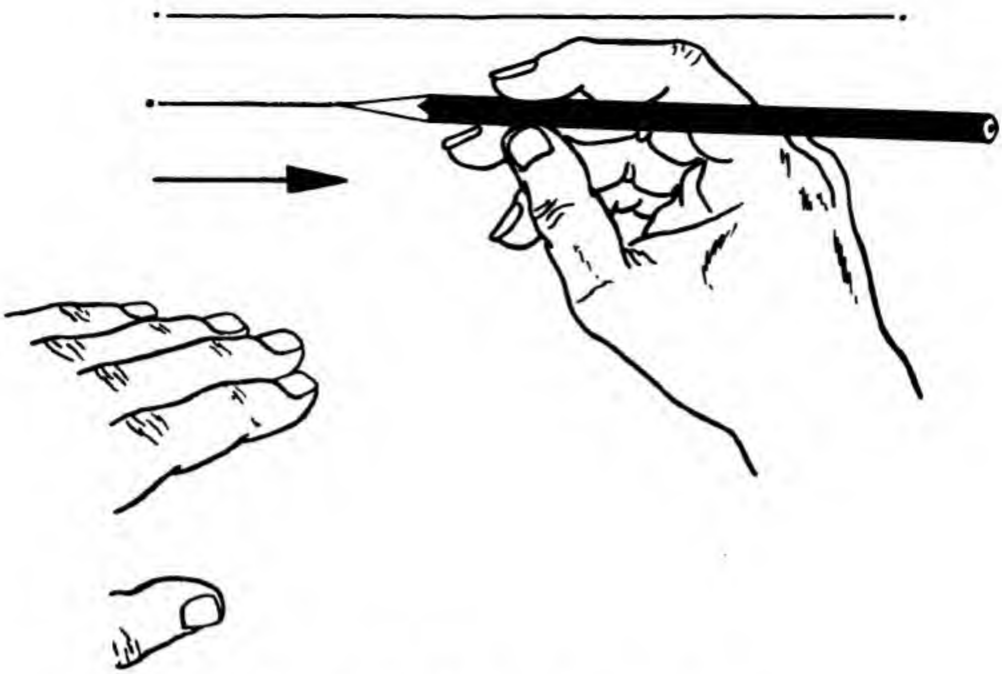


Figure 6-7.—Drawing horizontal lines.

with a small dot and then draw the line between the dots.
Horizontal lines are shown in figure 6-7. One has been drawn and the start of the second line suggests the method. You may want to locate one or more dots between the end dots when the line is to be a long one. Try drawing several horizontal lines and, after each one is drawn, examine it for both straightness and weight. If it is too light, either a softer pencil or a little more pressure is necessary.

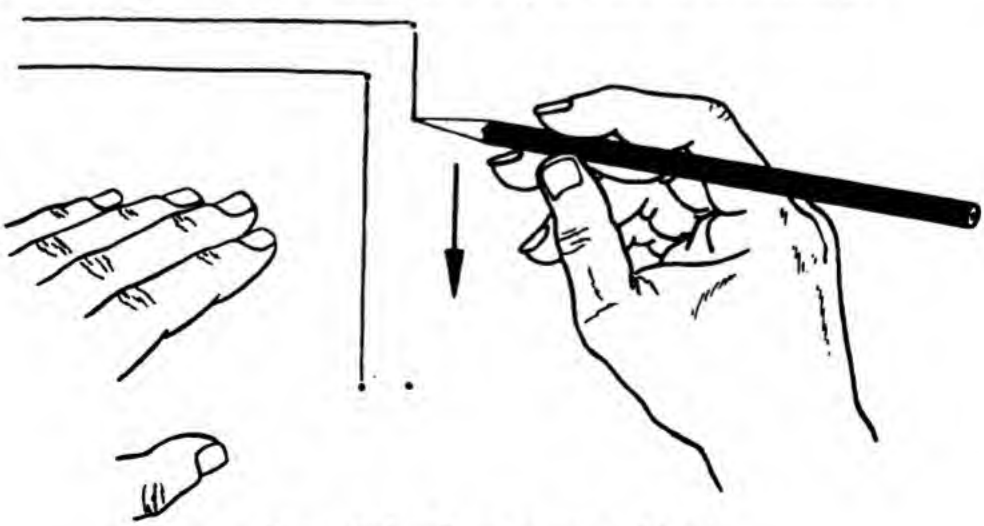


Figure 6-8.—Drawing vertical lines.

Vertical lines are usually sketched downward on the paper as shown in figure 6-8. The same suggestions for using locating dots and free movement of the entire arm apply to vertical lines as they do to horizontal lines.

Slanting lines, several of which are shown in figure 6-9, may be drawn from either end toward the other. The arrows indicating the direction in which the lines in this figure were drawn therefore show only one way to draw them.

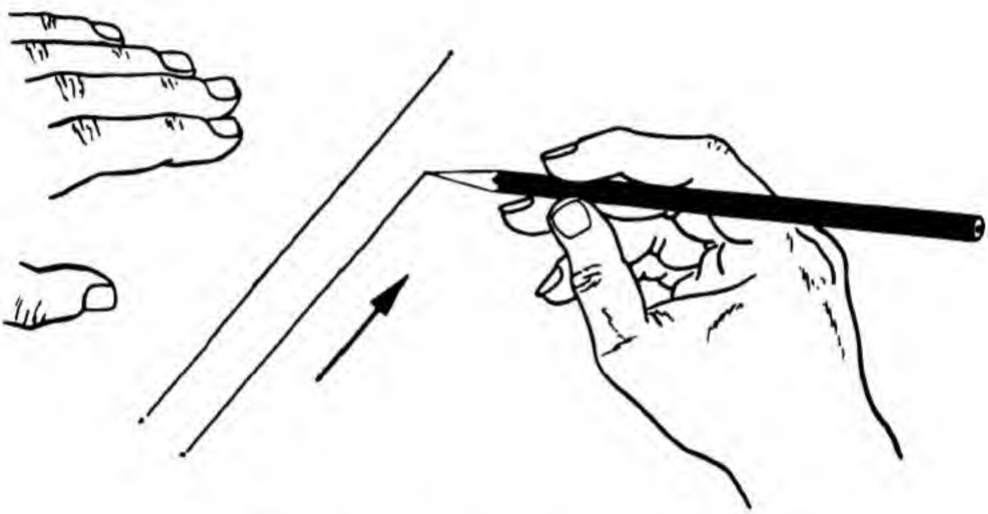


Figure 6-9.—Drawing slanting lines.

Using only horizontal lines, vertical lines, and slanting lines, it is possible to make any number of complete and acceptable technical sketches, depending, of course, on the item or job to be sketched. Figure 6-10 is a perspective assembly sketch of a demonstration exercise for five kinds of welded joints showing the several pieces set up before being welded. Like the perspective assembly sketch of the oil filter shown in figure 6-1, this sketch looks like the actual item as it would appear on the welding bench. Only horizontal, vertical, and slanting lines were used to make it.

Technical sketches frequently include many circles or arcs. You don't need to be gifted with artistic talent to draw good circles if you will follow these suggestions.

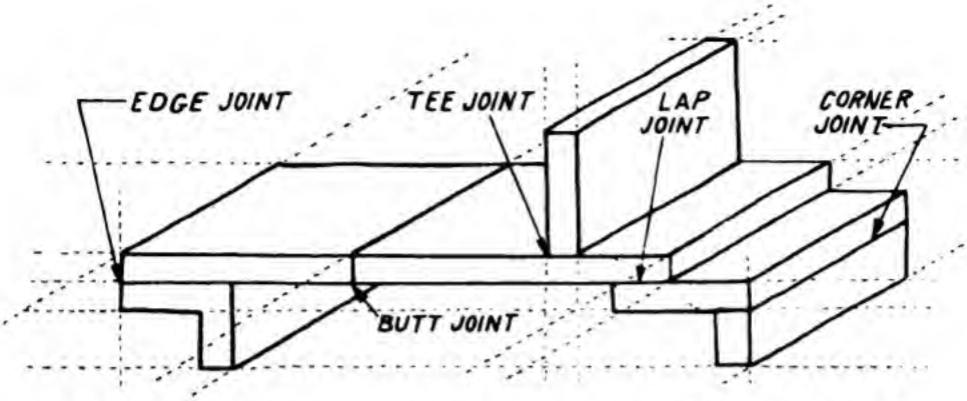


Figure 6–10.—Horizontal, vertical and slanting lines combined.

At A in figure 6–11 see how the pencil is held beneath the four fingers with the thumb. This hold tends to produce a "soft" or "easy" motion for sketching large circles or curves and also makes it possible to sketch small circles as shown in figure 6–11 B and C. You will notice in figure 6–11 B that the second finger rests at the center of the circle and forms the pivot about which the pencil lead can swing. The distance from the finger tip to the pencil lead determines the radius of the circle. To draw smaller circles a somewhat different hold on the pencil is necessary, as shown in C, but the principle is the same. Figure 6–11 shows the proper ways to hold the pencil; figure 6–12 shows how to draw the circles using these holds.

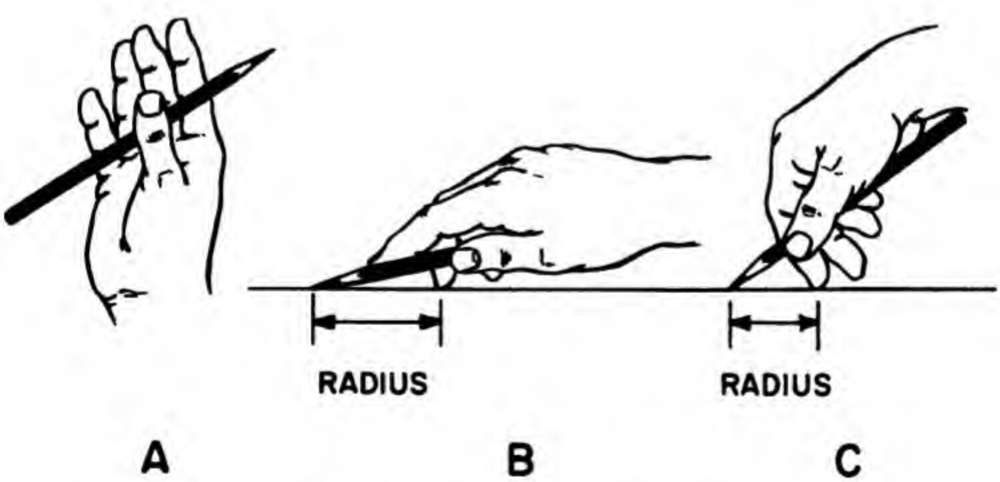


Figure 6–11.—Circles and arcs.

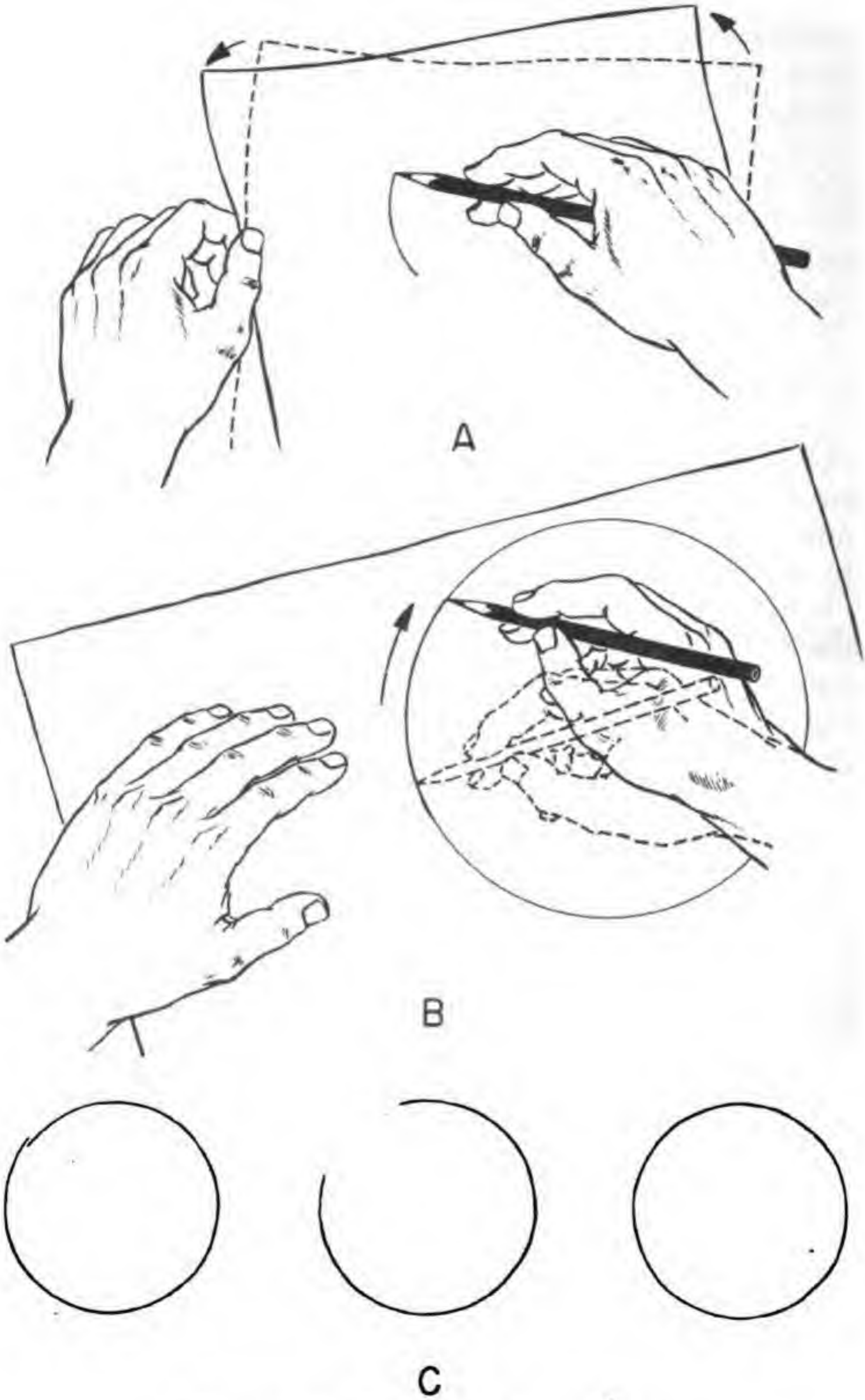


Figure 6–12.—Steps in sketching a circle.

As shown at A in figure 6–12, the first step in sketching either large or small circles with the holds shown in the previous figure is placing the second finger on the paper at the center of the proposed circle. Then, with the pencil lightly touching the paper, use the other hand to rotate the paper to give you a circle that may look like the one in figure 6–12B. To correct the slight error of closure shown in C, erase a substantial section of the circle and correct it by eye as shown at the right. You now have a complete and round circle, but only with a very light line which must be made heavier. Do this as shown in B. Notice that you do NOT pivot on the second finger during this step. You rest your hand on its side, keep it within the circle, and trace over the light line with your hand pivoting naturally at the wrist. As you work around the circle in this way, rotate the paper counterclockwise so that your hand can work in the most natural and easy position as shown. With the smaller circles you cannot of course work with your hand within the circle, but the same general approach can be used with success.

PERSPECTIVE SKETCHING

Only a few people are naturally gifted with the knack of being able to make a sketch in which the perspective is exactly as it should be to have the object look natural. But everybody, with the aid of some basic rules, can help himself acquire real ability to put on paper that which he may have in mind or be looking at. A perspective sketch, in which the object looks just as it actually does look, can best be made by adhering to the following few simple and basic rules or principles:

1. Select a position that will show the object to the best advantage. You will know what you want included in your sketch, so move either the object or yourself until you can actually see everything you want to show. If the object is something you have "in mind," or if you have an orthographic drawing—a blueprint—of it, you will have to visualize the object and assume a viewing position. Remember

that you want to make a perspective sketch with a realistic appearance, in other words, one that looks just like the object itself.

2. Sketch only what you actually see from the viewing position you have selected. You cannot include anything you do not see and still have a correct perspective sketch.

3. As horizontal lines recede, they must converge so that they tend to meet at the vanishing point.

4. Start by lightly sketching in the principal lines, extending each one towards the vanishing point. In figure 6–13, which is a perspective sketch, there is only one vanishing point. It is sometimes called a one-point perspective. All faces of the object which are in planes parallel to the front plane are shown in approximately their true shape. Notice how all receding lines tend to meet (and would if they were extended) at a single vanishing point.

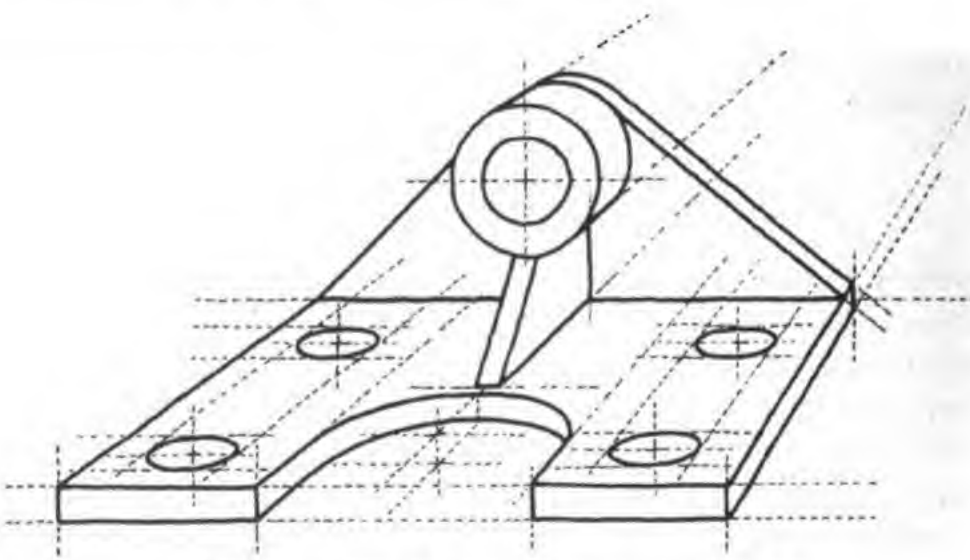


Figure 6–13.—A one-point perspective sketch.

In figure 6–14 which is called an angular perspective sketch, there are two vanishing points and no front plane as there was in the preceding figure. You are viewing the object from an angle. This is a two-point perspective in which all horizontal lines receding to the right extend toward a vanishing point at the right. All horizontal lines receding to the left extend toward a vanishing point at the left.

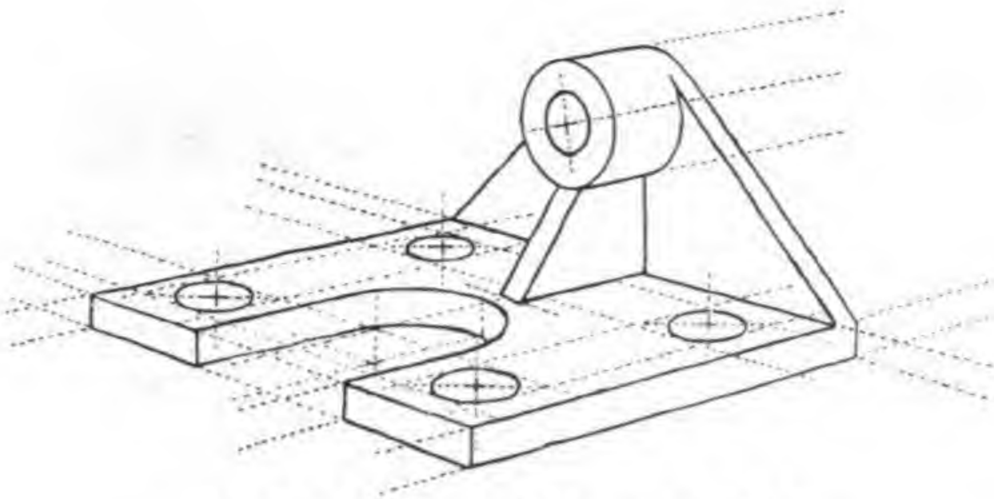


Figure 6–14.—A two-point perspective sketch.

Vanishing points are always at eye-level and on the horizontal line regardless of whether the perspective sketch is a one or a two-point perspective. If you are looking down at the object, the vanishing point or points, and the horizon, will be above the object. If you are looking up at the object, the vanishing point or points, and the horizon, will be below the object.

5. Block in the enclosing perspective squares for circles, slots, and other features. Then add the outlines for minor details.

6. Darken the object lines and erase the light construction lines previously extended beyond the figure toward the vanishing point.

QUIZ

1. How much information should be included in a technical sketch?
2. To what standards should technical sketches be made?
3. A sketch showing a complete unit or assembly just as it looks is called a ____________________.
4. A sketch showing one of the component parts of an assembly, just as the part looks is called a ____________________.
5. A sketch showing three views of an assembled unit or object, with no perspective, is called ____________________.
6. A sketch showing three views of one part of an assembly, with no perspective, is called ____________________.
7. A complete set of technical sketches would include one __________ sketch and one __________ sketch of each part.
8. The sketches in question 7 could be either __________ or __________ sketches.
9. What do you include in a perspective sketch?
10. How do you select the viewing position?
11. What is probably the greatest advantage to being able to do technical sketching with facility?
12. What manipulative advantage do you have with sketching over mechanical drawing?
13. List the minimum equipment necessary to make a technical sketch.

CHAPTER · 7

CURVE OR BEND ALLOWANCE

WHAT IS BEND ALLOWANCE?

You'll see curves practically every time you see a bend line on a blueprint. Bending is the forming operation most frequently used in aircraft construction. If bending metal is one of the skills included in your rating, then, unless you know how to master the curve in bending metals, you will always have trouble in your layout work.

First of all you must realize that a curved corner takes less metal than a square corner. This is demonstrated in figure 7–1.

The problem is to figure out how to cut the stock the right length before you bend it. This is where you'll need to know the BEND ALLOWANCE (abbreviated B. A.), that is, how much metal to allow for each bend.

Aluminum alloy of any thickness may be bent cold, provided it is done over a properly rounded corner. This curvature at the bend is referred to as the BEND RADIUS. It is the inside radius of the curve, as shown in figure 7–2.

In figure 7–3 you will see a sheet of metal held in place between the mandrel and bed of a bending brake. When the folding wing is raised, the piece to be bent will be brought upward through the number of degrees required for the bend and the radius of the bend will correspond to the radius of the mandrel around which the metal is being bent.

The required radius varies both with the grade and the thickness of the alloy. No specific value can be set up for the radius at which a sheet of a given material and thickness

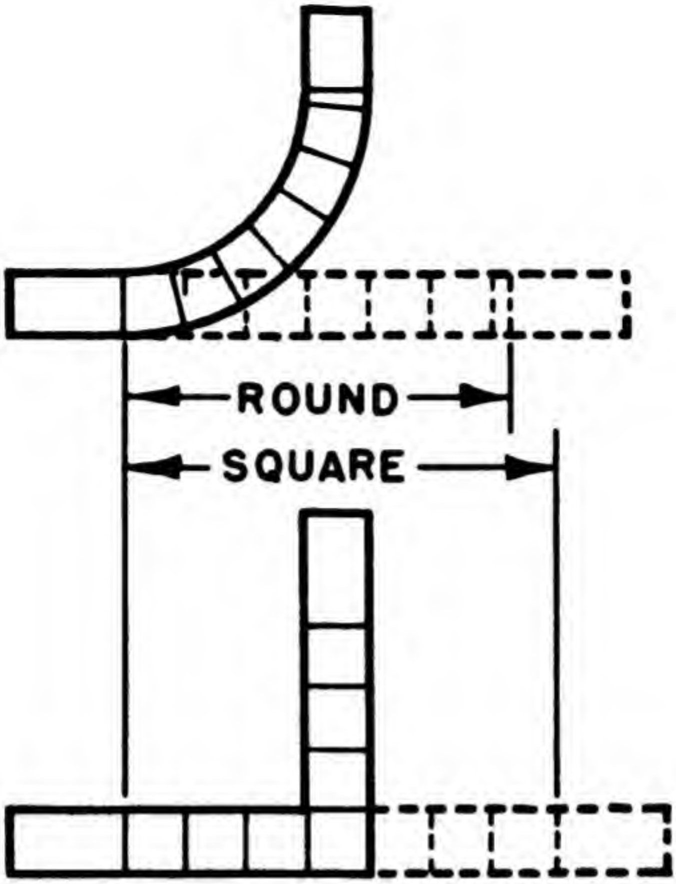


Figure 7-1.—Variations in material required for round and square corners.

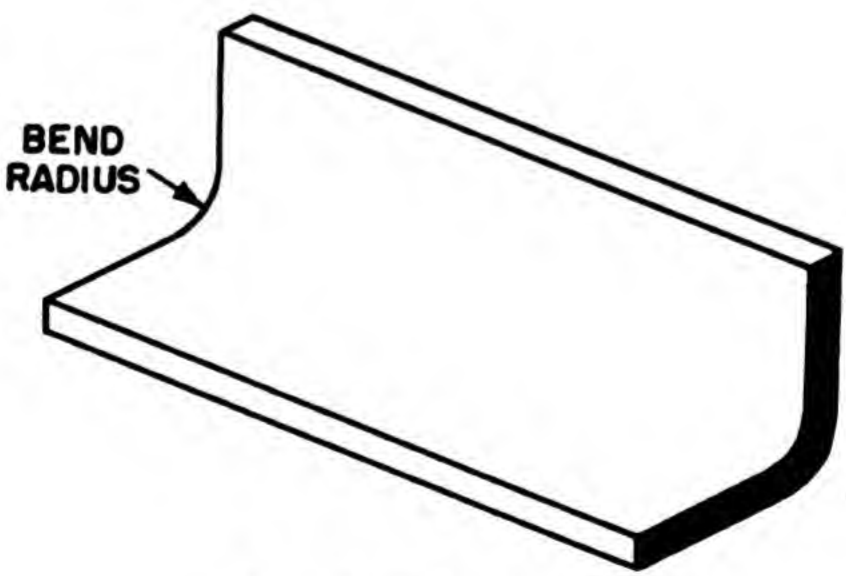


Figure 7-2.—Bend radius.

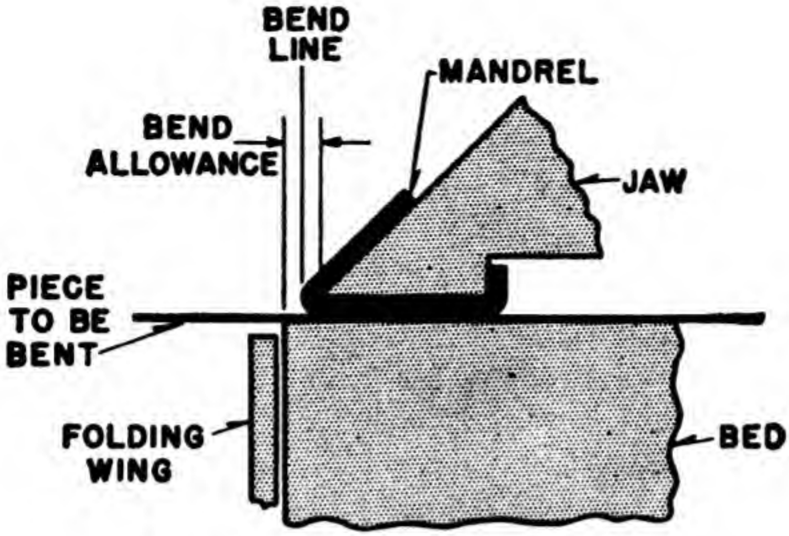


Figure 7–3.—Sheet ready for bending.

must be bent. There are, however, minimum radii which are generally accepted. Taken from the bend allowance table universally used in the aircraft industry, these radii are shown in figure 7–4. Use appendix III when you want to convert fractions or decimals.

In addition to using the proper bend radius, the actual amount of material used to form the bend must be known if accurate results are to be obtained. The amount of material which is actually used in making the bend is known as BEND ALLOWANCE, illustrated in figure 7–5.

Theoretically, the bend allowance for a 90° bend would be

RADII REQUIRED FOR 90° BENDS IN ALUMINUM ALLOY

Approximate Thickness

Alloy	0.020	0.025	0.028	0.032	0.040	0.045	0.051	0.057	0.064	0.072	0.081	0.128
17SO.. 24SO..	0	1/32	1/32	1/32	1/16	1/16	1/16	3/32	3/32	1/8	1/8	7/32
17ST..	1/32	1/16	1/16	1/16	3/32	1/8	1/8	5/32	5/32	5/32	1/4	5/16
24ST..	3/32	1/8	1/8	1/8	5/32	3/16	3/16	3/16	3/16	7/32	5/16	1/2
24SRT	1/32	1/8	1/8	1/8	5/32	3/16	3/16	1/4	1/4	9/32	7/16	5/8

Figure 7–4.—Minimum radii chart.

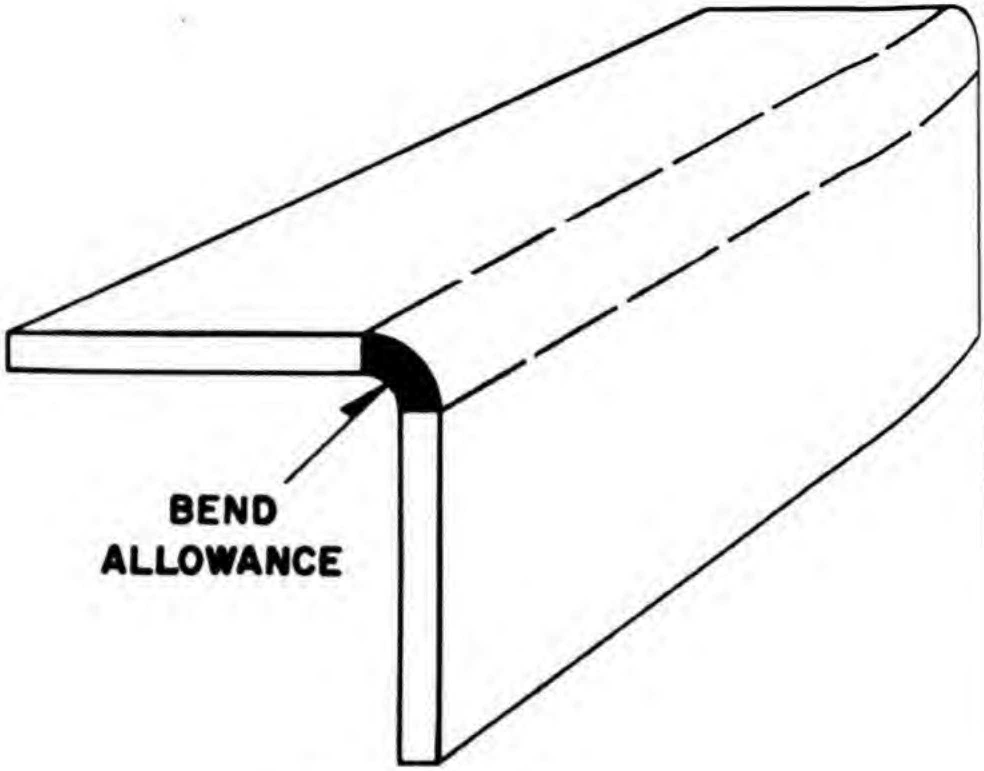


Figure 7–5.—Bend allowance.

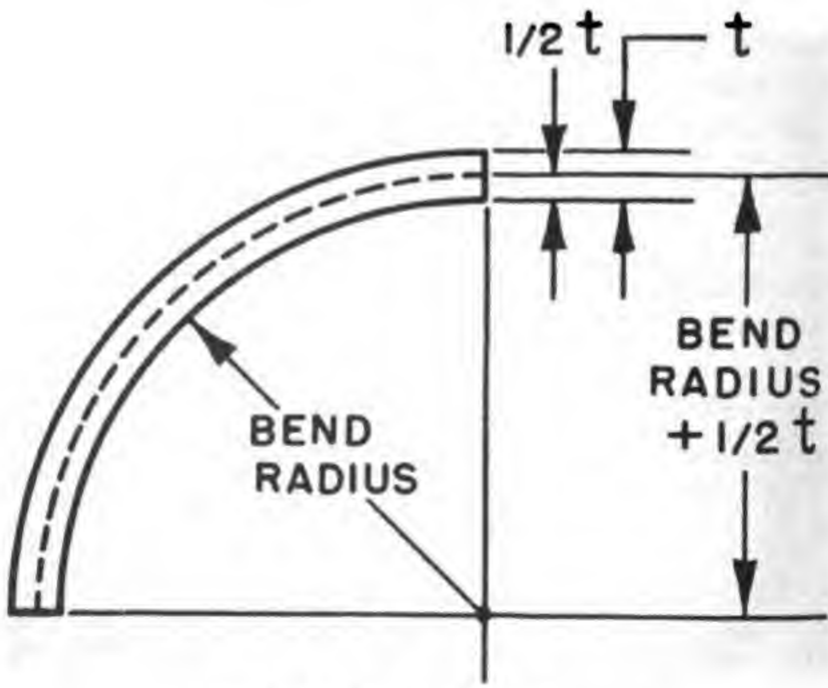


Figure 7–6.—Bend radius allowance.

equal to one-fourth of the circumference of a circle whose radius is equal to the bend radius, plus one-half the thickness of the metal. This is illustrated in figure 7–6.

For bends greater or less than 90°, the bend allowance would be more or less, respectively, than one-fourth of the circumference.

In actual practice, however, bend allowance does not work out so simply. The bend allowance is affected by the shrinking and stretching of the metal at the bend. This varies with the different bend radii, the thickness of the metal used, and its type and temper. Aircraft engineers have developed methods for determining the bend allowance and have found, by actual bending, the effect of the factors just mentioned. Before discussing methods of determining bend allowances, we must first understand what happens when metal is bent and why the amount of material required for the bend varies.

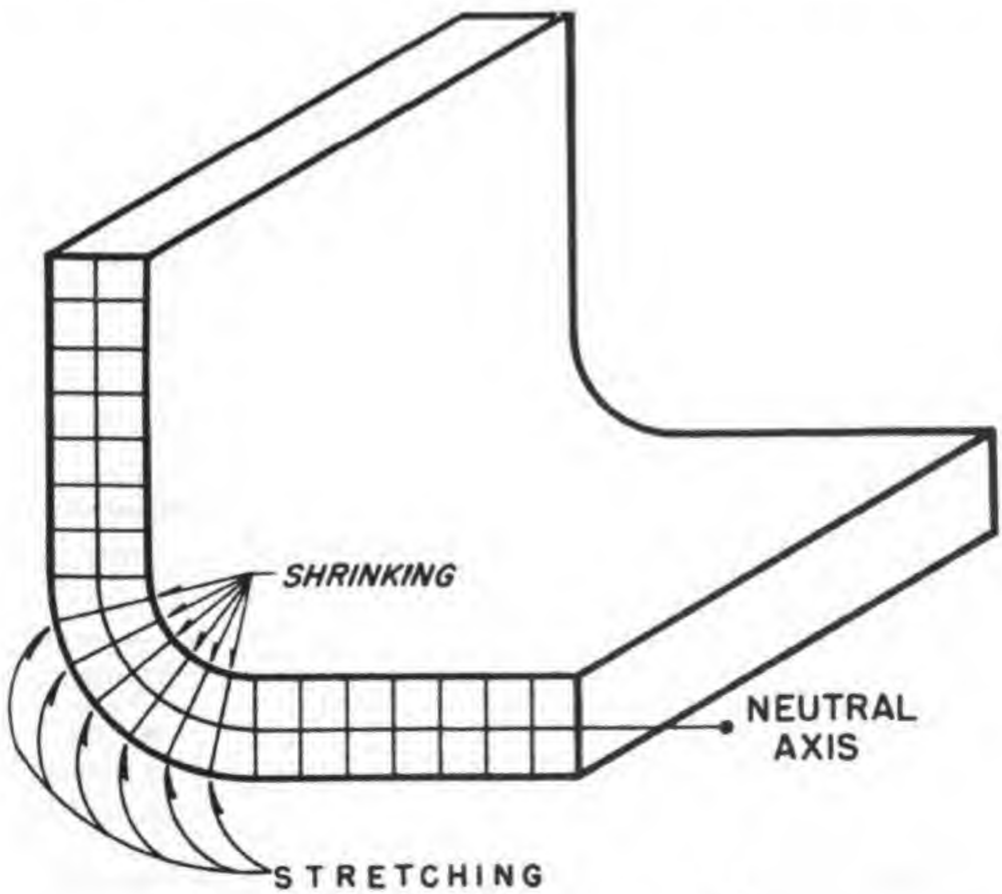


Figure 7–7.—What happens at a bend.

When metal is bent, the outside of the bend is stretched or lengthened, while the material on the inside is forced to shrink or shorten.

When a sheet is being bent, the metal along a line through the middle of the thickness of the sheet is a neutral zone, where neither shrinking nor stretching occurs. This line occupies the same length, when bent, as a straight line, indicating that the bend allowance is figured along the neutral axis, as shown in figure 7-7.

BEND ALLOWANCE FORMULA

Theoretically, the amount of material required for a 90° bend could be figured as the circumference of a quarter of a circle, but in actual practice this is inaccurate due to the variation in physical properties of different metals. Some accurate basis must be used to determine the bend allowance for various bends. As has been mentioned, aircraft engineers have worked out a formula based on numerous experiments with actual bends in metal. This formula can be used to determine the bend allowance required for different bends from 1° to 180°. This bend allowance formula with an example is given in figure 7-8.

The letters used in the bend allowance formula (and the setback formula later) are explained as follows:

R—desired bend radius.

t—thickness of material.

N—number of degrees which the material will be bent.

BEND ALLOWANCE FORMULA B.A.=(.01743R + .0078 t) X N	
Formula in Use	Example
B.A.=(.01743 X .1875 + .0078 X .040) X 35 B.A.=(.003268 + .00031) X 35 B.A.= .003578 X 35 B.A.= .1253	N=35° t = .040 R = .1875

Figure 7-8.—Bend allowance formula.

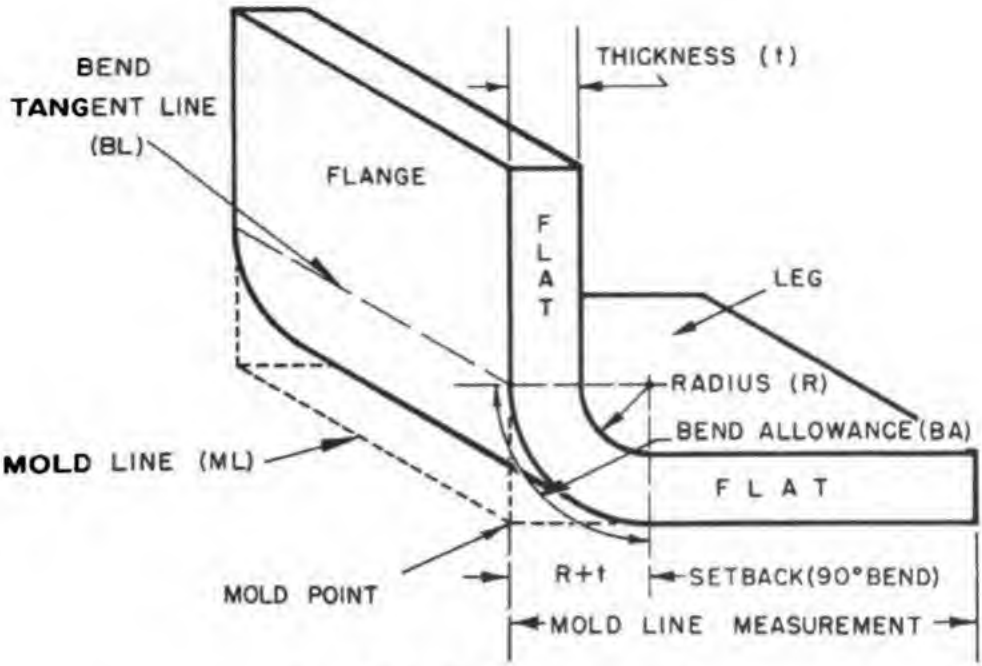


Figure 7–9.—Technical forming terms.

Knowing the bend allowance required for a bend is of value only if such knowledge is applied to the actual job of figuring the amount of metal needed. The length of material required includes all the flat and curved portions. After the length of these parts has been figured, a flat pattern layout is drawn either on paper or on the metal to be used.

TECHNICAL FORMING TERMS

Terms that must be considered when making straight line bends are defined below and illustrated in figure 7–9.

LEG.—The longer part of a formed angle.

FLANGE.—The shorter part of a formed angle. If each is the same length, each is known as a LEG.

MOLD LINE (*ML*).—The line formed by extending the outside surfaces of the leg and flange.

BEND TANGENT LINE (*BL*).—The line at which the metal starts to bend.

BEND ALLOWANCE (*B.A.*).—The amount of material consumed in making the bend.

RADIUS (*R*).—The radius of the bend—always to the inside of the metal being formed unless otherwise stated.

A°	K	A°	K	A°	K	A°	K
1	0.00873	46	0.42447	91	1.0176	136	2.4751
2	.01745	47	.43481	92	1.0355	137	2.5386
3	.02618	48	.44523	93	1.0538	138	2.6051
4	.03493	49	.45573	94	1.0724	139	2.6746
5	.04366	50	.46631	95	1.0913	140	2.7475
6	.05241	51	.47697	96	1.1106	141	2.8239
7	.06116	52	.48773	97	1.1303	142	2.9042
8	.06993	53	.49858	98	1.1504	143	2.9887
9	.07870	54	.50953	99	1.1708	144	3.0777
10	.08749	55	.52057	100	1.1917	145	3.1716
11	.09629	56	.53171	101	1.2131	146	3.2708
12	.10510	57	.54295	102	1.2349	147	3.3759
13	.11393	58	.55431	103	1.2572	148	3.4874
14	.12278	59	.56577	104	1.2799	149	3.6059
15	.13165	60	.57735	105	1.3032	150	3.7320
16	.14054	61	.58904	106	1.3270	151	3.8667
17	.14945	62	.60086	107	1.3514	152	4.0108
18	.15838	63	.61208	108	1.3764	153	4.1653
19	.16734	64	.62487	109	1.4091	154	4.3315
20	.17633	65	.63707	110	1.4281	155	4.5107
21	.18534	66	.64941	111	1.4550	156	4.7046
22	.19438	67	.66188	112	1.4826	157	4.9151
23	.20345	68	.67451	113	1.5108	158	5.1455
24	.21256	69	.68728	114	1.5399	159	5.3995
25	.22169	70	.70021	115	1.5697	160	5.6713
26	.23078	71	.71329	116	1.6003	161	5.9758
27	.24008	72	.72654	117	1.6318	162	6.3137
28	.25862	73	.73996	118	1.6643	163	6.6911
29	.25863	74	.75355	119	1.6977	164	7.1154
30	.26795	75	.76733	120	1.7320	165	7.5957
31	.27732	76	.78128	121	1.7675	166	8.1443
32	.28674	77	.79543	122	1.8040	167	8.7769
33	.29621	78	.80978	123	1.8418	168	9.5144
34	.30573	79	.82434	124	1.8807	169	10.385
35	.31530	80	.83910	125	1.9210	170	11.430
36	.32492	81	.85408	126	1.9626	171	12.706
37	.33459	82	.86929	127	2.0057	172	14.301
38	.34433	83	.88472	128	2.0503	173	16.350
39	.35412	84	.90040	129	2.0965	174	19.081
40	.36397	85	.91633	130	2.1445	175	22.904
41	.37388	86	.93251	131	2.1943	176	26.636
42	.38386	87	.94896	132	2.2460	177	38.188
43	.39391	88	.96569	133	2.2998	178	57.290
44	.40403	89	.98270	134	2.3558	179	114.590
45	.41421	90	1.00000	135	2.4142	180	Infinite

Figure 7-10.—Setback or *K* table.

SETBACK (SB).—The amount that the two mold line dimensions overlap when they are bent around the formed part. Setback must be figured with the aid of the K table, in figure 7–10, for bends of other than 90°. In a 90° bend $SB=R+t$.

BEND LINE (sometimes called BRAKE or SIGHT LINE).—The layout line on the metal being formed which is set even with the nose of the brake and serves as a guide in bending the work. See figure 7–16.

Setback

To make the flat layout accurately, not only the bend allowance for each bend but also the length of these flat portions between the curves must be determined. In order to determine the length of these flats, the setback for each bend must be found and subtracted from the base measurement. The K table, shown in figure 7–10, gives the constants necessary to enable you to calculate the setback for all degrees of bend. By multiplying the value given in figure 7–10 (which is known as constant K) by $R+t$, the distance from the reference line (mold line) to the bend tangent line is obtained. This distance is called the setback.

Figure 7–11 illustrates the setback formula and its use. Notice that N is the number of degrees which the material

SETBACK FORMULA

SETBACK=$K(R+t)$

Formula in Use	Example
Setback$=K(R+t)$ Setback$=0.31530(0.1875+0.040)$ Setback$=0.07173$	$N=35°$ $t=0.040$ $R=0.1875$ K(From Table) 0.31530

Figure 7–11.—Setback formula.

will be bent, t is the thickness of the material, and R is the bend radius.

SETBACK FORMULA APPLICATION

To illustrate the use of the bend allowance and setback formulas in figuring the amount of material needed for the flat layout and in locating the bends, a few typical problems are worked out. For a job involving two 90° bends we will use the problem subsequently used as an example for the simple flat layout method and shown in figure 7–17. The comparative accuracy of the simple method for this type of bend will be made evident. Figure 7–12 shows the problem in detail. The term "base measurement" means the same thing as "mold line measurement" shown in figure 7–9.

Procedure

1. Determine setback.
   Setback $= K(R+t)$.
   Setback $= 1(0.125+0.040)$.
   Setback $= 0.165$ or $^{11}/_{64}$.
2. Determine length of all flats (fig. 7–12).
   Flats A and $E =$ Base measurement $-$ setback.
   Flats A and $E = 1$ inch $- 0.165$.
   Flats A and $E = 0.835$ or $^{53}/_{64}$.
   Flat $C =$ Base measurement $- 2 \times$ setback.
   Flat $C = 3$ inches $- 2(0.165)$.
   Flat $C = 3$ inches $- 0.330$.
   Flat $C = 2.670$ or $2^{43}/_{64}$.
3. Determine bend allowance for all bends (at B and D).
   $B.\ A. = (0.01743\ R) + (0.0078\ t) \times N$.
   $B.\ A. = (0.01743 \times 0.125) + (0.0078 \times 0.040) \times 90°$.
   $B.\ A. = 0.2242$ or $^{7}/_{32}$.
4. Make the layout as shown in figure 7–13.
   Total length $= {}^{53}/_{64} + {}^{7}/_{32} + 2^{43}/_{64} + {}^{7}/_{32} + {}^{53}/_{64}$.
   Total length $= 4^{49}/_{64}$ or 4.77 (as compared to $4^{51}/_{64}$ or 4.80 by the simple method illustrated in figure 7–17).

The following outline lists the procedure for determining the flat layout for a job with open and closed angles. Figure 7–14 illustrates this procedure.

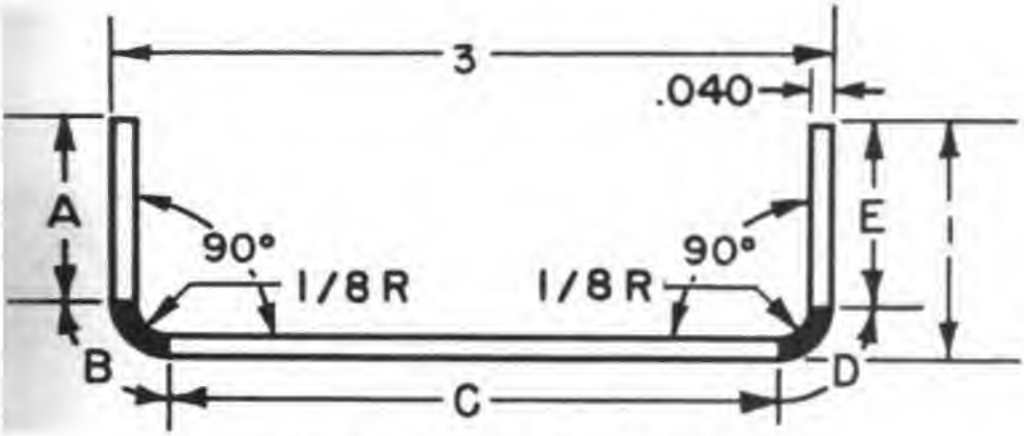


Figure 7-12.—Setback formula problem.

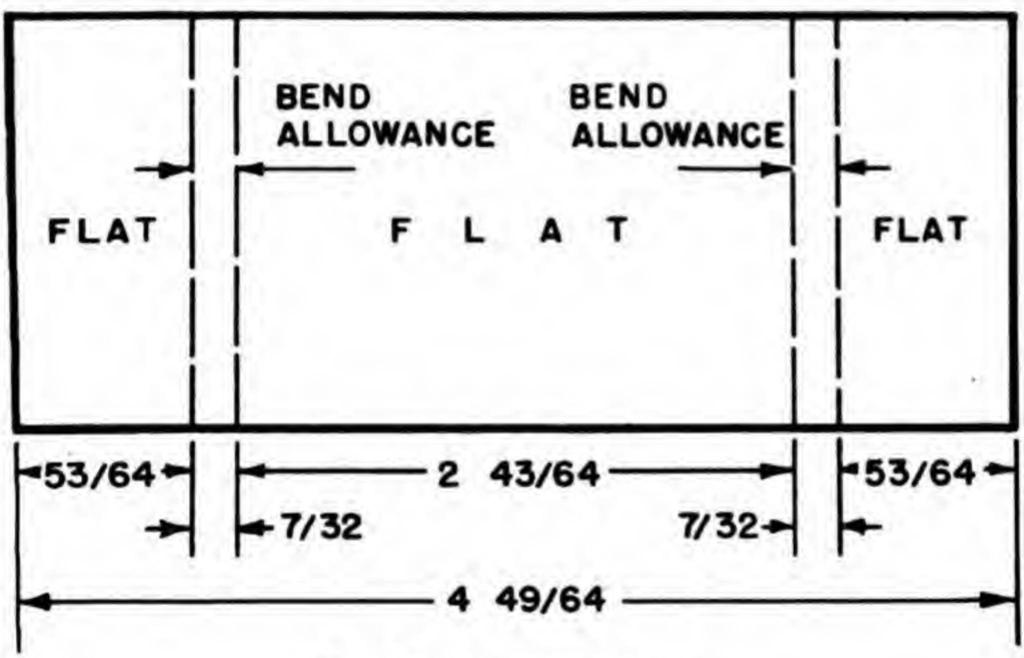


Figure 7-13.—Setback layout.

Procedure

1. Determine setback (fig. 7-14).
   Setback at $B=K\ (R+t)$.
   Setback at $B=2.4142\ (\frac{5}{32}+0.051)$.
   Setback at $B=0.499$ or $\frac{1}{2}$.
   Setback at $D=K\ (R+t)$.
   Setback at $D=0.4142\ (\frac{5}{32}+0.051)$.
   Setback at $D=0.0857$ or $\frac{5}{64}$.

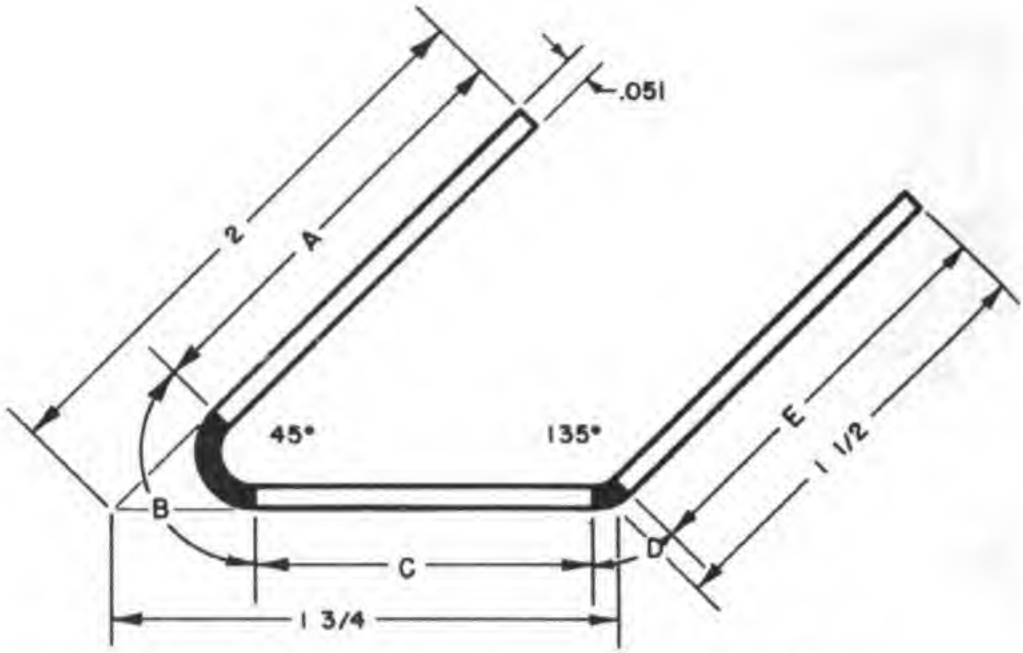


Figure 7-14.—Procedure for open- and closed-angle job.

2. Determine length of all flats (fig. 7-14).
   Flat A=Base measurement−setback at B.
   Flat A=2 inches−½.
   Flat A=1½.
   Flat E=Base measurement−setback at D.
   Flat E=1½−5/64.
   Flat E=1 27/64.
   Flat C=Base measurement−setback $B+D$.
   Flat C=1¾−(5/64+½).
   Flat C=1 11/64.
3. Determine bend allowance for all bends (fig. 7-14).
   $B. A.$ at B $(0.01743\ R)+(0.0078\ t)\times N$.
   $B. A.$ at B $(0.01743\times0.156)+(0.0078\times0.051)\times135°$.
   $B. A.$ at B (0.4207 or 27/64).
   $B. A.$ at D $(0.01743\ R)+(0.0078\ t)\times N$.
   $B. A.$ at D $(0.01743\times0.156)+(0.0078\times0.051)\times45°$.
   $B. A.$ at D 0.1402 or 9/64.
4. Make the layout as shown in figure 7-15.

In figure 7-15 the bend tangent lines indicate the portions which are bent. Before forming each bend, it must be decided which end of the material can be most conveniently

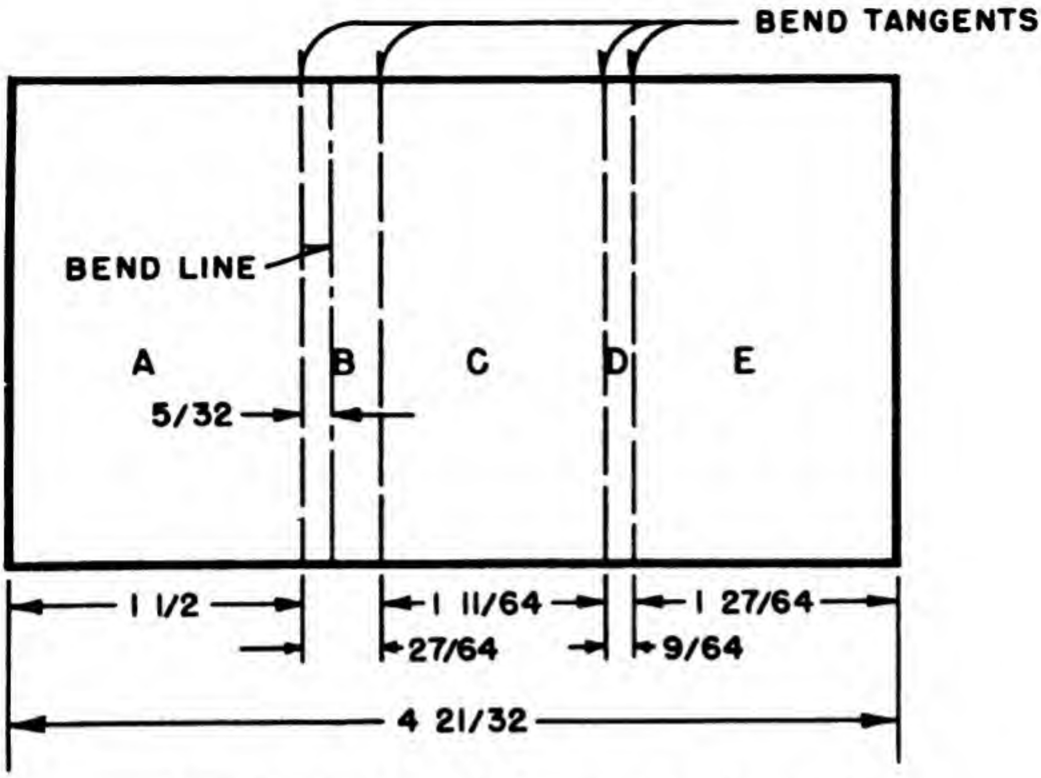


Figure 7–15.—Layout for open- and closed-angle job.

inserted in the brake. Then the bend line is measured and marked with a soft pencil from the bend tangent line closest to the end which is to be placed under the brake. This measurement should be equal to the radius. The metal is inserted in the brake so that the nose of the brake will fall directly over the bend line, as shown in figure 7–16.

SIMPLE FLAT LAYOUT BENDING METHOD

Figure 7–16 illustrates an accurate method of bending the flat layout which has one or two 90° bends. This method may be used for the majority of aircraft fabrication involving bending. It is applicable to only those 90° bends whose radius is equal to approximately 1, 2, or 3 times the thickness of the material. For example, where R equals $\frac{3}{32}$ (0.0937), and t equals 0.051, R equals $2t$ approximately. In using this method, the end of the sheet closest to the bend line must be inserted in the brake. The distance the bend line is located

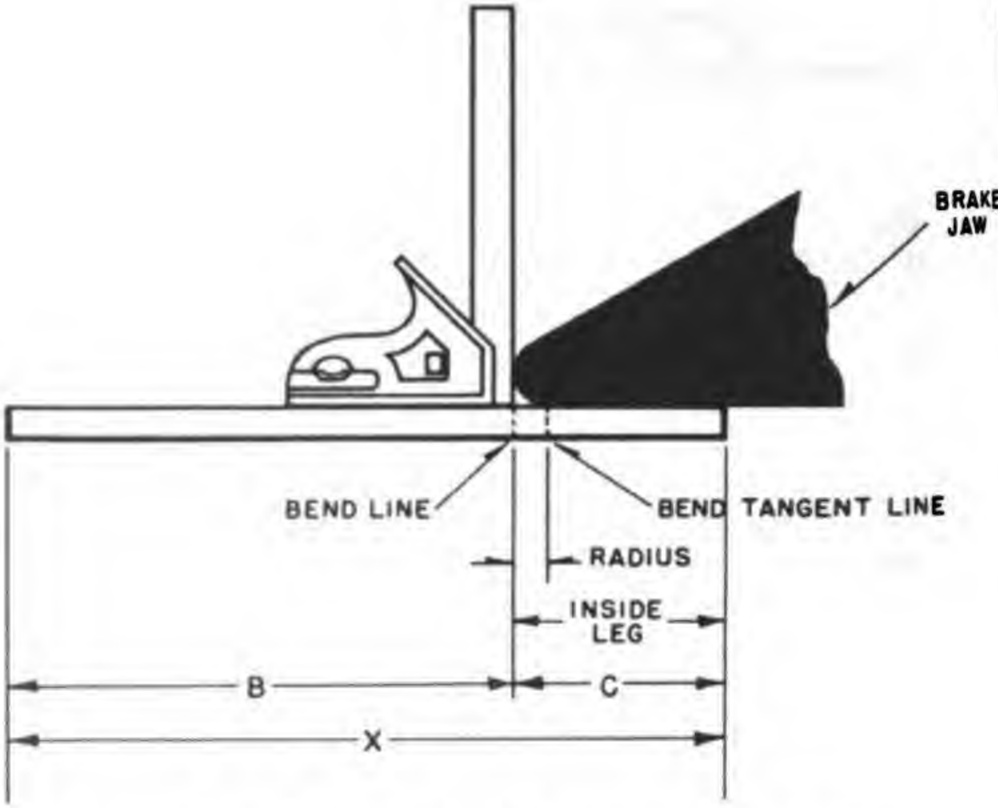


Figure 7-16.—Simple flat layout bending method.

from the end of the sheet is equal to the inside height of the flange or leg.

SIMPLE FLAT LAYOUT METHOD EXAMPLE

Figure 7-17 illustrates the dimensions for a flanged job which can be laid out by the above method.

$$R=0.125 \text{ (i. e., } R= \text{ approximately } 3t)$$
$$t=0.040$$

1. Determine inside dimensions.
   Inside height$=1.000-t$.
   Inside height$=1.000-0.040$.
   Inside height$=0.960$.
   Inside width$=3.000-2t$.
   Inside width$=3.000-0.080$.
   Inside width$=2.920$.

2. Determine overall length, as shown in figure 7–17.
Overall length $=0.960+0.960+2.920-2\ (0.040\div2)$.
Overall length $=4.80$ or $4\frac{51}{64}$.

3. Each bend is made by inserting the end of the metal under the jaw of the brake so that the bend line—which has been marked on the sheet with a soft-lead pencil—will be directly under the nose of the brake, as demonstrated in figure 7–16. The bend line here is 0.960 inch from the end of the sheet, as shown in figure 7–17.

FORMULA METHOD OF FLAT LAYOUT

As the name implies, the formula method of flat layout necessitates the use of the bend allowance and the setback formula when making a layout containing 1, 2, or more bends. The bend allowance must be determined in order to find the amount of material used in each bend, and the setback must be determined to locate the beginning of the bend.

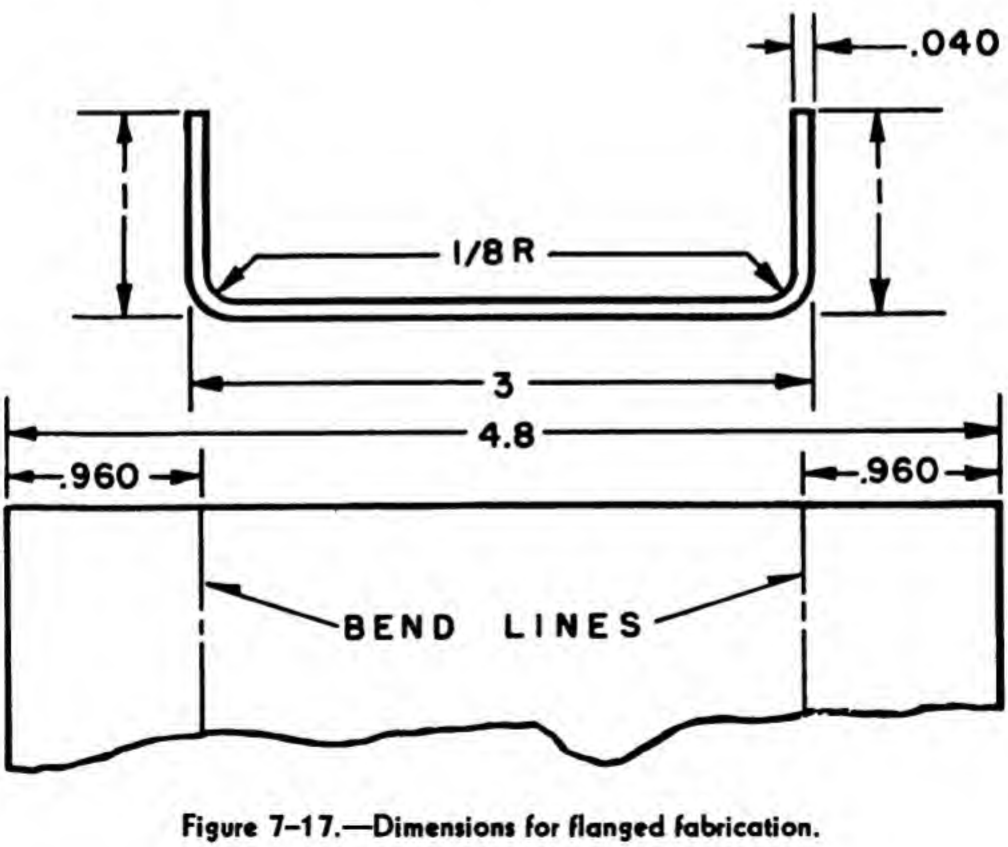


Figure 7–17.—Dimensions for flanged fabrication.

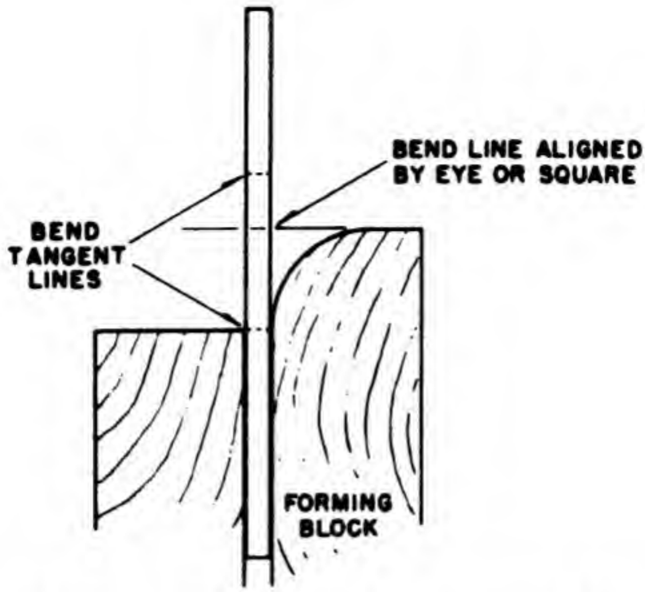


Figure 7–18.—Form blocks used for alinement of bend line.

The advantage of the formula method of layout over the simple method just discussed is its greater degree of accuracy. The formula method may be used for the flat layout of parts with any number and kinds of bends.

BENDING MACHINES

In working in the shop you'll discover that there are numerous ingenious machines that will solve your bending problems automatically—such as radius bars, die brakes, bending brakes, flange machines, and box brakes. But there will be times when you'll have no machines, and then you'll be thankful that you know how to figure bend allowance and set back so you can make an accurate and correct layout on the flat sheet of metal. Having that, many forming jobs can be done without machines. Figure 7–18 is typical of an improvised setup for bending metal without a machine.

QUIZ

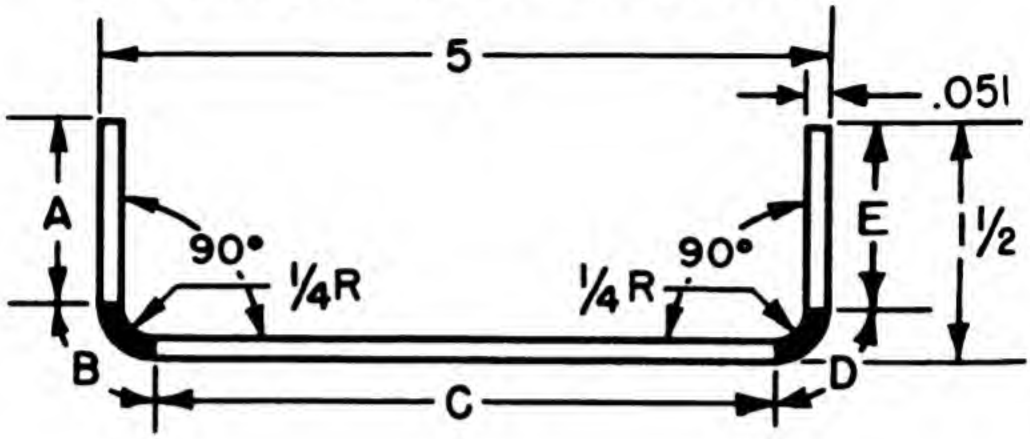
1. From where did the minimum radii come that are listed in figure 7–3, the minimum radii chart?
2. What is the theoretical bend allowance for a 90° bend equal to?
3. What surfaces would have to be extended to establish the theoretical edge called a mold line?
4. For what does the abbreviation *ML* stand?
5. If a mold line is a theoretical line or edge, how would it be represented or located on a drawing showing only the edges of the sheet?
6. What happens to metal along the bend when it is bent?
7. Where along a bend is there no internal stress, neither compression nor stretching (tension)?
8. Why is the neutral axis used for measurements?
9. What measurement is taken along the neutral axis?
10. What does the length of the curved portion of the neutral axis represent?
11. What do you call the extra length or amount of material?
12. To what is the radius of a bend always measured?
13. Using the minimum radii chart in figure 7–4, and the bend allowance formula in figure 7–8, find the *B. A.* for a 25° bend in 24ST aluminum, 0.032″ thick, bent to the minimum radius for this material and thickness.
14. Given:

    Bend radius required is ¼″.
    Material to be bent 44°.
    Thickness of material is 0.081″.
    Material to be 17SO aluminum.

    Required:

    a. Can this material of this thickness be bent around the required radius?
    b. If so, find the bend allowance.
15. Using the setback (*K*) table shown in figure 7–10, and the setback formula shown in figure 7–11, find the setback for a 30° bend in 0.032″ 24SRT aluminum which is to be bent to a radius of 5/32″.

16. Use the *SB* and *B.A.* formulas to locate the bends and to figure the amount of material needed for the flat layout of the 0.051 aluminum (24SO) job shown in the following drawing:



CHAPTER 8

TEMPLATES

ACCURACY REQUIRED

In this chapter you will read about templates and how they are made and used. You will be told of the many precautions that are taken when templates are made so that you will come to "know your templates." The reason templates are included in this book on *Blueprint Reading and Sketching* is that, in many ways, they serve the same purpose as a blueprint. They furnish information regarding size, shape, reference numbers, hole size and locations, and material specifications for the part that will subsequently be made from the template. It is true that this information also appears on the blueprint for the part, and you will check your template for accuracy—or actually make it in the first place—with the blueprint.

However, since you may often use templates in conjunction with blueprints to make parts—or even use them in place of blueprints in making such parts—you must know something about them. They are particularly useful if the need for the parts to be made is recurring, or if a large number of a single part is needed.

The measurements on templates MUST BE ACCURATE. The template is made first and is used in production work as a guide for making a number of duplicate parts. If it's wrong, all parts made from it are wrong.

The procedure followed in making a template is essentially the same as that used in making a layout. Templates are usually made of sheet steel, to withstand the wear and tear of shop use. But in spite of the sturdy metal, templates become damaged or inaccurate from use.

Don't work with an inaccurate template. Get out the blueprint and make a new template.

Since you are going to be working in metal to limits of ± 0.010 or ± 0.003 inch, you'll have to have a magnifying glass. No guesswork is permitted when you make templates.

You can't use a pencil or a pencil compass, because neither makes a sufficiently sharp outline. For all template work you'll use scribers and dividers, to make the sharpest outline possible. And for further accuracy you'll use your magnifying glass—to transfer dimensions from scales, to set dividers, and to check up on the accuracy of scribed lines.

MAKING A TEMPLATE

In making a template you'll need to figure the *B.A.* if the part has a bend. The man who makes a part from your template wants to be sure you figured the *B.A.* before he starts cutting the metal. The geometric construction and *B.A.* are all a part of the usual layout job. But you'll vary the layout procedure slightly.

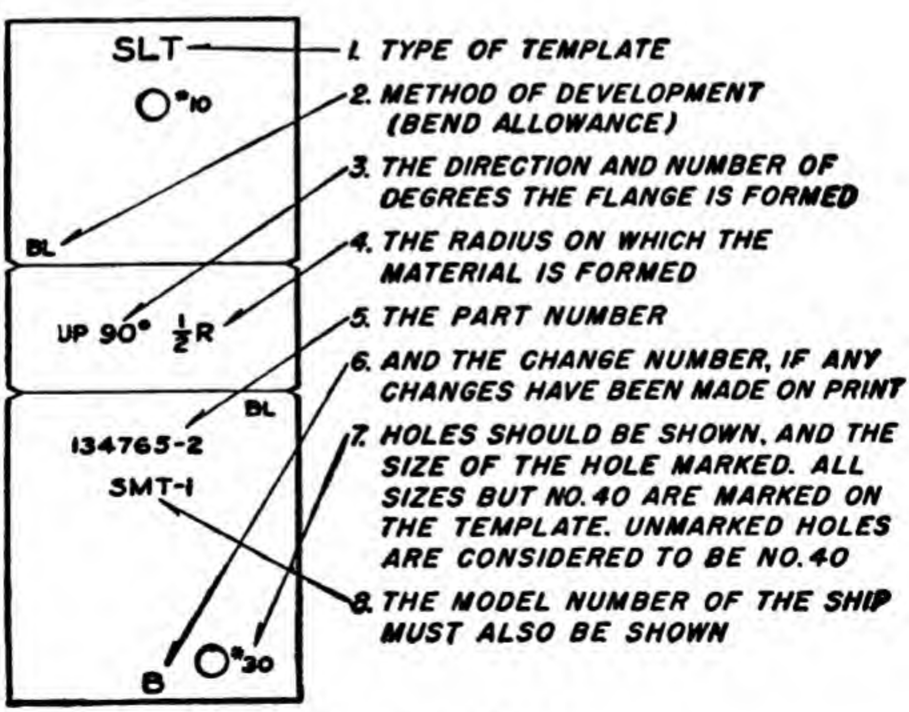


Figure 8–1.—Template.

In the first place, this is one time when you're expected to mark on the surface.

Study figure 8-1. The information and instructions listed are all a part of a template. They're there so that anyone can make a part simply by reading the directions.

SLT is an abbreviation for steel layout template.

BL is an abbreviation for bend line.

Notice that two notches have been cut into the template on the left-hand and right-hand edges. They're there to help you transfer the *BL's* to the work. The rest of the information is self-explanatory.

HOLES

In order to achieve the highest degree of accuracy, the holes in template work are punched. They are never drilled. The purpose of the template holes is to specify location, not size. For this reason a punch of a specific diameter—either ⅛ inch or 5/32 inch, depending upon instructions—can be used for all the holes.

When transferring hole locations from the template to the work, use a transfer punch. This punch will fit exactly in the punched hole on the template. When you strike it with a hammer, you'll make a center punch mark on the work underneath.

Once you have a center punch mark, you are ready to start drilling. The size of the drill you should use is given on the face of the template.

BEND RELIEF HOLES

Wherever bends intersect the metal tends to "crowd." This "crowding" causes the metal to bulge at the intersection and sets up internal stresses which can eventually cause the metal to fail.

This danger can be avoided by locating a relief hole at the intersection of bends. It is then possible to cut away the material at the intersection so that the flange and leg will be independent of each other. By doing this you can avoid strains on the metal where the bends meet.

There are several types of relief holes (fig. 8–2). Blueprints will always specify which type you should make.

In *a* the relief hole is located at the intersection of the inside bend lines. The diameter of the hole is usually calculated as being four times the thickness of the metal. This type of relief hole is particularly effective when rivets or bolts have to be put close to corners.

In *b* the radius point is at the intersection of the centerlines of the two sets of bend lines. You'll probably use this type of relief hole more frequently than any other.

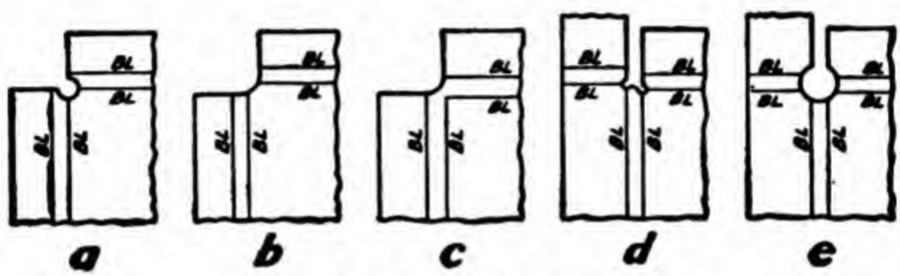


Figure 8–2.—Types of relief holes.

In *c* the point for the radius is at the intersection of the two outside bend lines. This type of relief hole can be used only on soft stock; it's especially good for watertight construction that does not require welding. Such a corner may be used to make compartments watertight, by placing a compound-saturated cloth over the hole; or it may be used in a corner where stringers or stiffeners come through a bulkhead.

In *d* three bends meet.

In *e* you see the same problem, but the hole has been modified. It's easier than the method shown in *d*. Simple fabrications also keep construction time down.

TABS

Occasionally you'll be able either to save time or prevent the loss of a template by putting tabs on the template.

For instance, the template shown at the left in figure 8–3 has two tabs. The large tab has a hole, drilled especially to take the pilot of a sheet metal punch. This punch has a

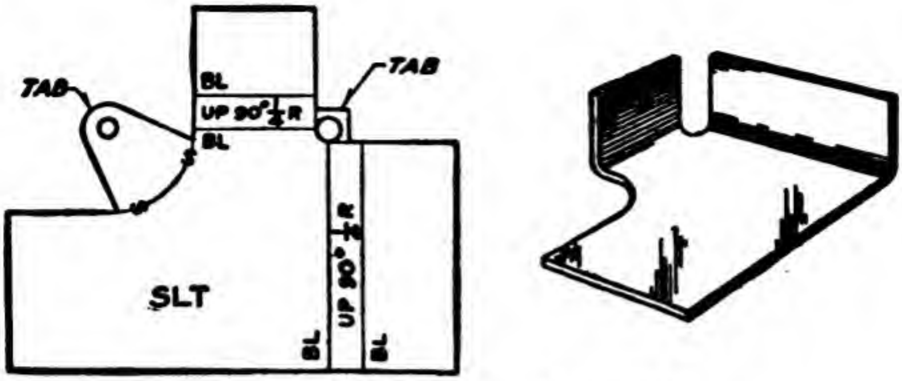


Figure 8-3.—Template with two tabs.

curved edge which will cut out the radius in one operation.

When you see the letter *S* in a line, you should cut along that line. The *S* stands for SHEAR.

The small tab is useful, too. You can use it to center a round punch for making the small radius. After the hole has been made in the sheet, you can make straight cuts, leaving the radius clear.

Before you make a tab of this kind, check up on your equipment. You'll need special tools for the punching.

The perspective drawing shows the part as it would be made. The tabs have been removed.

The template shown in figure 8-4 is mostly tab.

A small template is hard to work with and is easily mislaid. But a large tab lets you get a good hold on the template, so that you can keep it in position when scribing around it.

Because there's more room on the tab than on the template, the template information has been put on the tab.

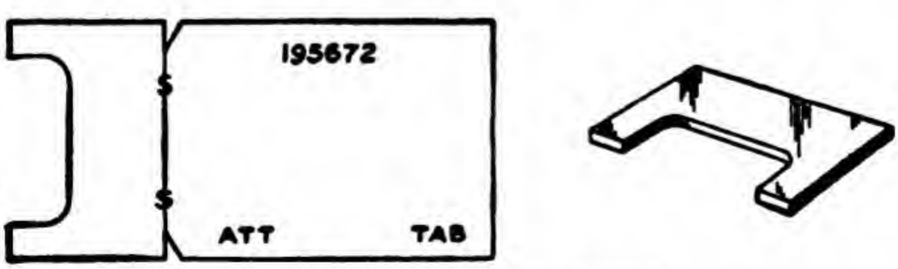


Figure 8-4.—Template with large tab.

MORE THAN ONE

In laying out a template that has more than one flange, first select a base—usually the largest section of the final part. The base shown in *a* of figure 8-5 is the section, *A*, to which the flanges are attached. Then add the *B.A.*'s as shown in *b*. Next add the two flanges. Notice that a small tab is indicated. That's to make sure that the relief hole is properly positioned.

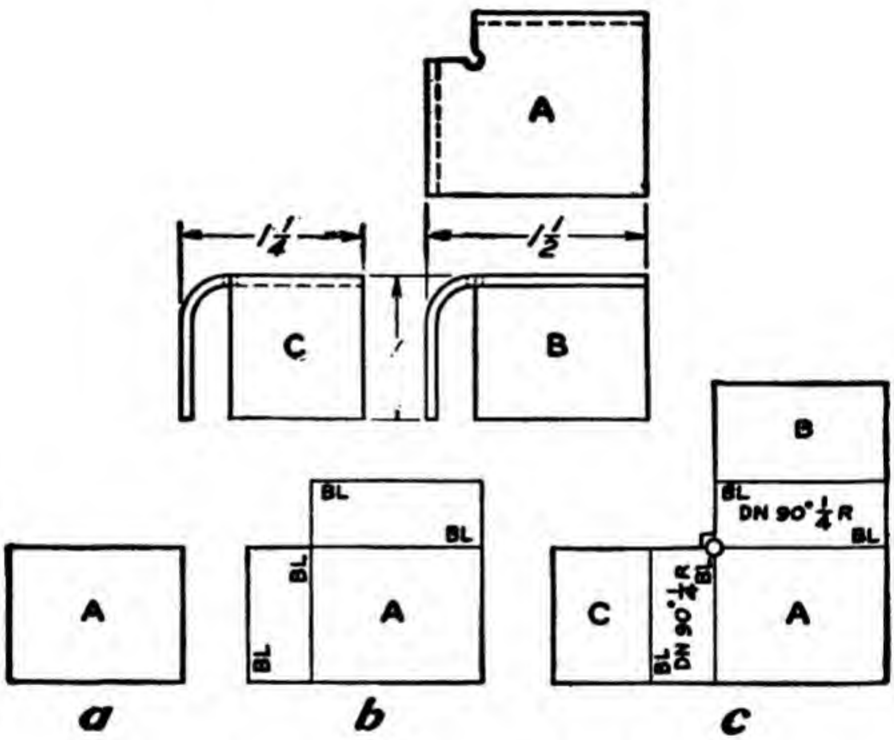


Figure 8-5.—Template with more than one flange.

When you transfer *BL*'s and centerlines to your work—in fact, any line that will not be removed by cutting—use a pencil.

QUIZ

1. For what is a template used?
2. Why are templates made to such close tolerances?
3. Name three rules for template-making which are intended to insure accuracy.
4. What do relief holes relieve?
5. What should you do if you find a template has become inaccurate from use?
6. What tool do you use to transfer hole locations from the template to the work?
7. How does a transfer punch work?
8. A tab may be used to locate the pilot of a sheet metal punch which will then ______________ a radius.
9. A tab may also be used to locate a small punch to ____________.
10. Why are tabs sometimes larger than the template?
11. On a small template with a large tab, where will you find the template information?

CHAPTER 9

ELECTRICAL AND ELECTRONIC BLUEPRINTS

INTRODUCTION

In order to understand and maintain the maze of electrical wiring throughout a ship and to service electrical and electronic equipments, a technician must be able to read electrical blueprints. It can easily be seen that confusion would exist if for each ship there were not a complete set of accurate electrical wiring prints—for even though ships of the same type or class look alike, there are always some differences in their actual wiring layouts. The technicians must constantly refer to these prints when tracing circuits if an efficient job is to be done. The technician would be lost in a maze of parts and wiring unless specific equipment wiring and schematic prints were available for reference.

This chapter is designed to acquaint concerned personnel with the types and uses of electrical and electronic blueprints.

TYPES

There is a great deal of information on electrical and electronic blueprints if all the aspects for the circuits of each are to be included. If all this necessary information, physical and electrical, for the description of one major circuit were placed on a single blueprint, either the print would be too large for effective use or the information would be so jammed together that it would be nearly impossible to read.

There are therefore four basic types of electrical and electronic blueprints to which a technician may refer:

ELEMENTARY, ISOMETRIC, WIRING PLANS and SCHEMATICS. For shipboard wiring only the elementary, isometric and wiring plans are used. Both elementaries and schematics are essential when working on the INTERNAL circuitry of electrical or electronics equipments.

SYMBOLS

As there are many blueprints issued by activities within the Naval Establishment, as well as many others furnished by contract equipment manufacturing companies, there has been developed a standard set of symbols and reference designations for use in electrical and electronic blueprints. These standard symbols and reference designations are contained in Military Standards pamphlets (Mil-Std). They are approved by the Departments of the Army, Navy and Air Force prior to service use. Mil-Std 15A and 16A are the current publications which contain the symbols and reference designations for electrical and electronic blueprints.

To reduce further the complexity of blueprint reading, cable tracing, and location of associated units, a standard set of markings has been developed for identifying electrical units and cables. The present usage designations were issued in 1949 in the Bureau of Ships Publication "General Specifications for Machinery for Vessels of the United States", section 28–2. As of 1 July 1954 these specifications have been revised into a new section 28–2. However, these revised designations are to be used only on NEW CONSTRUCTION vessels. The following paragraphs discuss each system.

PRESENT USAGE DESIGNATIONS (1949)

In general all marking of equipment is by name plate. Stamping or stenciling of characters on equipment is not used for marking except where specifically required or approved. Name plates should be located in a readily accessible position where they can be read at all times without danger to personnel. When a name plate is mounted on a panel or switchboard, it is close to the equipment to

which it refers, and is generally either directly above or directly below it.

Numbering Electrical Units

It will help you to remember, while you are reading electrical prints, that numbering which appears on the print also appears on the actual gear. It will also help to know that, in general, the system followed in assigning numbers to various electrical units conforms to the following rules:

Beginning with the lowest, forward, starboard compartment, all similar electrical units in that compartment are numbered before proceeding to the next compartment.

In the next compartment to the forward one, on the same level and the next inboard or to port of the first, this same procedure is continued, working from starboard to port and from forward to aft, until all units on that level have been numbered. Then, this same procedure is followed on the next upper level.

Within a given compartment, then, the numbering of

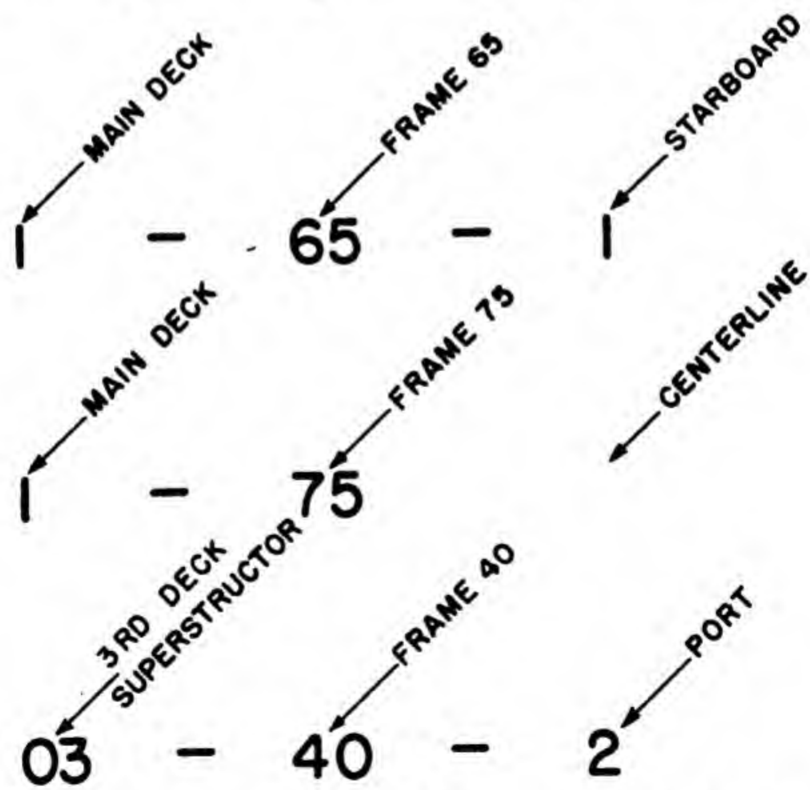


Figure 9–1.—Name plate markings for distribution panels.

similar units follows the same rule; that is LOWER takes precedence over UPPER, FORWARD takes precedence over AFT, and STARBOARD takes precedence over PORT.

Distribution panels, load center panels, and bus transfer equipment for lighting and power are numbered as follows:

Each panel or bus transfer unit bears a number related to its location (deck, frame number, and whether starboard, port or centerline). See figure 9–1. For purposes of showing deck locations of this equipment, a vessel is divided in all cases, using the main deck as the starting point. The numeral 1 is used for the main deck, and each successive deck above is numbered 01, 02, 03, etc., and each successive deck or platform below the main deck is numbered 2, 3, 4, etc.

To show a particular location on a deck, the frame number is used for the fore-and-aft position, and even and odd numbers are used for port and starboard locations respectively. For panels located on the centerline, no numeral is assigned. Figure 9–1 illustrates these markings.

Switch Marking

Switches and circuit breakers mounted on distribution switchboards are provided with name plates. These name plates are located directly above each feeder knife switch or circuit breaker and include (1) feeder letter and number; (2) name of equipment controlled; (3) load in amperes; and (4) trip element or fuse rating. Fuses for instruments have similar name plates which designate the circuit and fuse rating. Name plates for ship's service lighting and battle power feeders have red markers, and the handles of knife switches and type-ACB circuit breakers of these circuits are red.

Switches and circuit breakers on lighting and power distribution panels and bus-transfer equipment are provided with circuit name plates located adjacent to the handles of each switch or circuit breaker. These name plates include (1) circuit letter and number; (2) load in amperes; (3) location of apparatus or space served; (4) name of apparatus or circuit controlled; and (5) trip element or fuse rating.

Phase and Polarity Markings

Switchboard buses are marked with their phase identification or polarity. Terminals on the backs of switchboards are provided with name plates. These name plates include (1) circuit letter and number, and (2) phase identification or polarity.

The letters "A", "B", and "C" are used to identify the phases in 3-phase systems. The standard phase sequence in the Navy for lighting and power switchboards, distribution panels, feeder distribution boxes, junction boxes, and connection boxes is in the order A–B–C from top to bottom. When the observer is facing the front of a switchboard, the sequence is A–B–C from right to left, and when he is facing the rear of the switchboard, the sequence is A–B–C from left to right. The color coding on cables for 3-phase systems is black, white, and red for phases A, B, and C respectively. Phase sequence determines the direction of rotation of 3-phase motors. Reversal of the phase sequence reverses the direction of motor rotation.

The positive, neutral, and negative polarities of d-c buses, terminals, and cables are denoted respectively by black (+), white (±), and red (−). All terminal lugs in distribution panels are stamped with the circuit letter and number. Bus bar and main supply lugs are stamped with the phase letter (A, B, C) or polarity sign (+, ±, −), as applicable.

Cable Markings

All ship cables are readily identified by means of cable tags which give their source, relative importance, and classification for the purposes of maintenance and replacement. The metal strip upon which the identification marking for a cable is made is defined here as a cable tag (tags are shown in figure 9–2). Color markings, where required, are INCORPORATED IN THE CABLE TAG as specified later.

Classification of Circuits

Electric power cables and circuits are classified according to SERVICE, IMPORTANCE, and SOURCE.

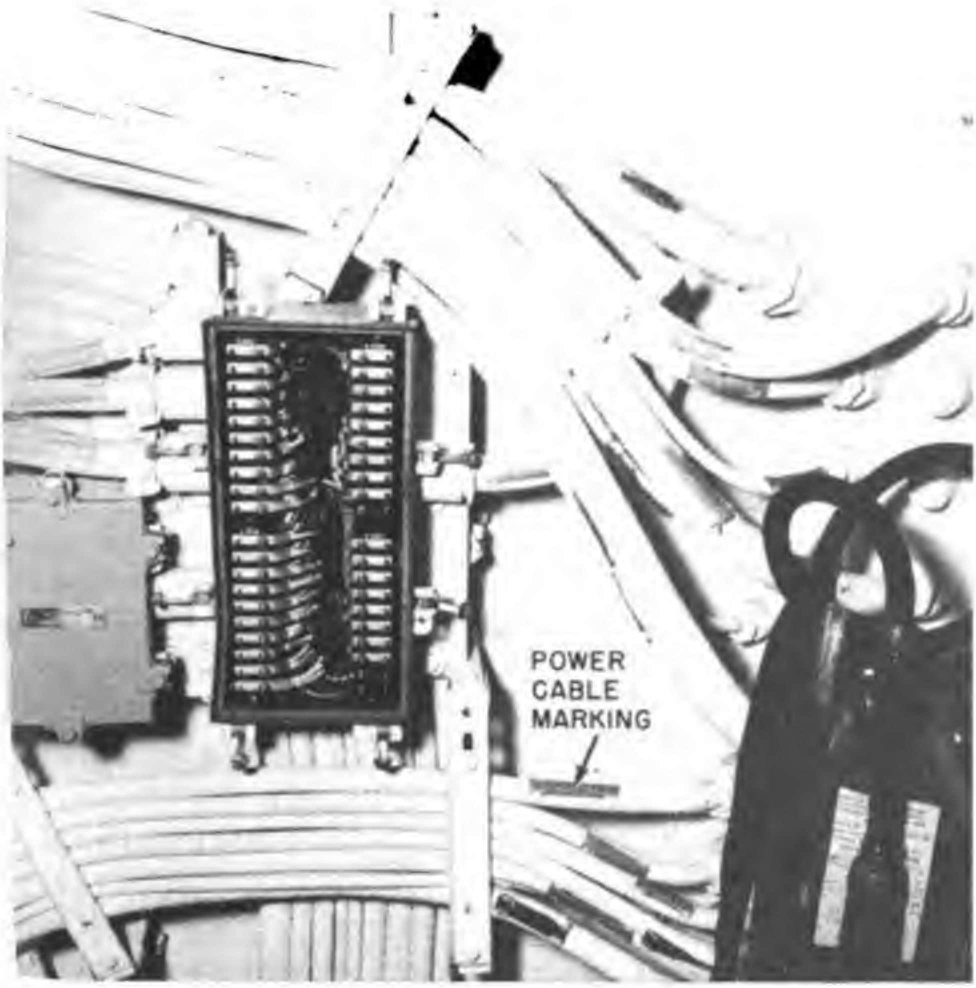


Figure 9–2.—Power cable marking.

Service.—All electric cables and circuits are classified to designate the particular type of equipment that they serve. These services are denoted by the following letters embossed on all cable identification tags:

C—Interior communications.

D—Degaussing.

F—Ship's service lighting and general power.
FB—Battle power.
G—Fire control.
MS—Minesweeping.
P—Electric propulsion.
R—Radio and radar.
RL—Running, anchor, and signal lights.
S—Sonar.
XFE—Emergency lighting and emergency power.

IMPORTANCE.—Power and lighting cables and circuits are classified into vital, semivital, and nonvital groups according to their importance. These groups of circuits are identified by means of colored cable tags as follows:

Vital circuits	red.
Semivital circuits	yellow.
Nonvital circuits	gray.

All permanently installed ship's cables are tagged as close as practicable to each point of connection. Cables are tagged also on both sides of decks, bulkheads, or other barriers (fig. 9–2). The distance between tags in cable runs must not exceed 50 feet.

SOURCE.—The source of lighting and power cables is denoted by means of cable numbers. These numbers indicate the cable voltage; the feeder from which the cable emanates; and whether the cable is fed from a forward or after switchboard. Letters and numerals following the cable number denote whether the cable emanates from a main, submain, or branch.

The terms "feeder," "main," "submain," "branch," and "subbranch" are used when referring to lighting and power cables. A feeder is a cable emanating from a switchboard; a main is a cable emanating from a feeder; a submain is a cable emanating from a main; a branch is a cable emanating from a submain; and a subbranch is a cable emanating from a branch.

Feeders connected to forward switchboards have odd numbers and feeders connected to after switchboards have even numbers. In installations that have only one switchboard, the feeders that run in a forward direction have odd

numbers and those that run in an after direction have even numbers.

Feeders are divided into (1) regular feeders that supply power to the ship's auxiliaries, and (2) feeders that supply power for particular applications. For example, the markings of regular feeder number 411 for the successive cables from a switchboard to a load are:

FB–411	feeder.
1–FB–411	main.
1–FB–411–A	submain.
1–FB–411–A1	branch.
1–FB–411–A1A	subbranch.

The first numeral of the feeder number indicates the voltage of the system—that is, feeder numbers for a 117-volt lighting system range from 100 to 199 inclusive, and those for a 450-volt power system range from 400 to 999 inclusive.

The latter group of feeders that supply power for particular applications includes bus-tie cables; excitation cables; feeder cables to lighting distribution switchboards; feeder cables to load-center panels; generator cables; shore connection cables; and switchgear group interconnecting cables. These feeders are designated by a cipher prefixed to the feeder number—as FB–0401 denotes a generator feeder.

Figure 9–3 illustrates a blueprint of a partial (after switchboard) shipboard electrical distribution system with cable and unit markings as they should appear. From the foregoing text all markings shown can be easily identified for power originating at a port side ship's service generator—the number of feeders, mains, submains, etc., and the location of the fed units.

NEW DESIGNATIONS SYSTEM (1954)

Because of the increase in electrical equipment aboard the modern warship, the 1949 designation system became very cumbersome and, in some instances was ambiguous in identification data. The Bureau of Ships therefore developed and instituted the system now being used on new construction, a description of which follows.

In general the new system of numbering electrical units

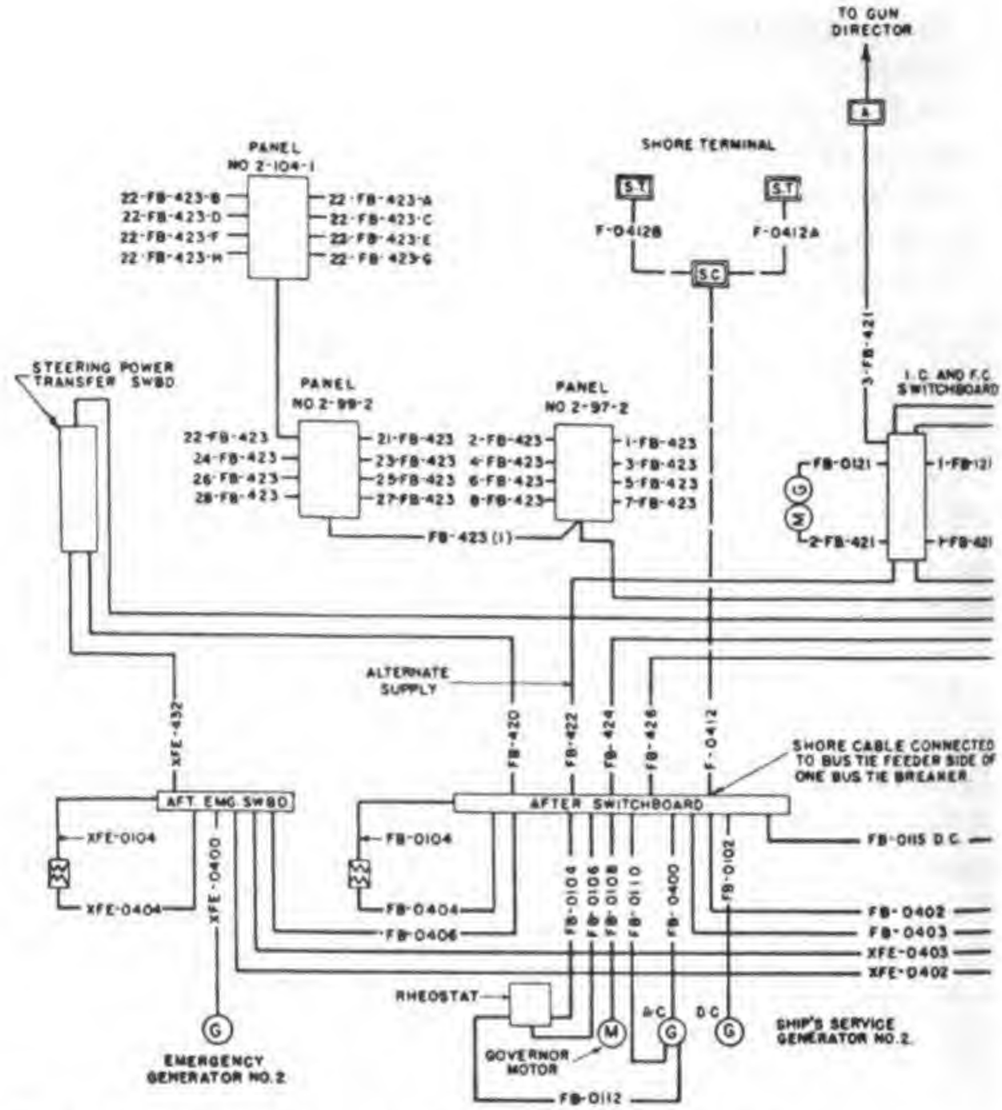


Figure 9–3.—Blueprint of a partial shipboard electrical distribution system.

still conforms to the 1949 system but the designation symbols have been changed as described in the following paragraphs.

POWER AND LIGHTING EQUIPMENT

The following special requirements apply to numbering electrical equipment for power and lighting:

SWITCHBOARDS. Switchboards or switchgear groups supplied from generators are designated:

Switchboards for ship's service generators—1S, 2S, etc., as necessary to designate all ship's service switchboards;

Switchboards for emergency generators—1E, 2E, etc., as necessary to designate all emergency switchboards;

Switchboards for special (other than frequency of ship's service generators) frequency a-c generators—1SF, 2SF, etc., as necessary to designate all special frequency switchboards.

In these designations the initial number denotes the number of the switchboard, determined in accordance with the previously discussed general rules for numbering. The letter S denotes ship's service, the letter E emergency, and the letters SF special frequency.

Sections of a switchgear group other than the generator section are designated by an additional suffix letter, beginning with the letter A and proceeding in alphabetical order from left to right, facing the front of the switchgear group.

Load center switchboards and miscellaneous switchboards used on ship's service a-c systems are given an identification number. If zone control distribution is used, the first digit indicates the zone and the second the number of the switchboard within that zone, determined in accordance with the general rule for numbering. If nonzonal distribution is used, the first number designates the deck on which the switchboard is located, the second number indicates the frame, and the third number indicates whether port or starboard in the same manner as these numbers are determined for distribution panels.

Transformers are designated by the letters TF, Motor Generators by the letters MG, and Rectifiers by the letters RT.

Cable and Conductor Identification

The general requirements for tagging cables and conductors are the same as in the 1949 system. However, the designation of power and lighting cables is made up of three parts in sequence, (1) source, (2) voltage and, (3) service and, where practical, destination. These parts are separated by hyphens. For cables that have normal and alternate or emergency feeders, the source designation contains first the source of the normal feed and second, separated by a slant

line, the designated source of the alternate or emergency feed. For example 1S/2S, 1S/2E, etc.

The following table of letters is used to designate the various cable services:

TABLE 1.—CABLE SERVICE DESIGNATIONS

Service	Designation
Degaussing	D
Electronics	R
Fire Control	G
Interior Communications	C
Lighting, emergency	EL
Lighting, navigational	N
Lighting, ship's service	L
Minesweeping	MS
Power, ship's service	P
Power, casualty	CP
Power, control	K
Power, special frequency	SP
Power, emergency	EP
Power, propulsion	PP

The destination of cables beyond panels and switchboards is designated except that each circuit receives alternately a letter, a number, a letter, and a number, progressively, every time that it is fused.

Generator Cables

For the purpose of designating power cables between generators and switchboards, generators are given numbers for cable marking purposes only. These numbers must not appear on the generator label plate.

If only one generator supplies a switchboard, the generator has the same number as that of the switchboard plus the letter G. Thus: 1SG denotes that only one ship's service generator is supplying a ship's service switchboard.

The numbers used to designate voltage should conform to the following table:

TABLE 2.—VOLTAGE DESIGNATIONS

Volts	Designation [1]
0–99	([2])
100–199	1
200–299	2
300–399	3
400–499	4
500–599	5
600–699	6
700–799	7
800–899	8
900–999	9
1,000–1,999	10
2,000–2,999	20
3,000–3,999	30
4,000–4,999	40
5,000–5,999	50

[1] For a 3-wire d-c system or a 4-wire 3-phase system the cable voltage designation indicates the higher voltage.

[2] Voltages below 100 volts are designated by the actual voltage (e. g. 24 for 24-volt circuit).

If more than one generator supplies a switchboard, the first generator determined in accordance with the general numbering rule will have the letter "A" immediately following the designation; the second generator that supplies the switchboard will have the letter "B," etc. Thus 1SGA and 1SGB would designate cables from two generators supplying number 1 switchboard. Table 3 illustrates the use of the foregoing discussion on cable markings.

Figure 9–4 illustrates a partial section of a typical shipboard blueprint of a power and lighting system using the new numbering and designating system.

TABLE 3.—TYPICAL POWER AND LIGHTING CABLE DESIGNATIONS

Cable Name	Designation	Remarks
Generator cable	6SG–4P–6S	For ship's service switchboard supplied from a single generator.
	6SGA–4P–6S 6SGB–4P–6S	For ship's service switchboard supplied from two generators.
	2SFG–10SP–2SF	For special frequency switchboard supplied from a single generator.
	1EG–4EP–1E	For emergency switchboard supplied from a single generator.
Bus-tie cable	6S–4P–7S	Between two ship's service switchboards.
	3S–4P–2E	Between a ship's service switchboard and an emergency switchboard.
	1SF–10SP–2SF	Between two special frequency switchboards.
Switchgear section interconnecting cable.	3S–4P–3SB	Between generator section and section B of the switchgear group.
	3SA–4P–3SB	Between sections A and B of the switchgear group.
Bus feeder	6S–4P–31	For ships with zone control.

Feeder	31–4P–(3–125–2)	For ships with zone control.
	31–4P–A	For ships with zone control.
	2S–4P–(4–152–1)	For ships without zone control.
	2SF–10SP–(5–52–4)	For ships with or without zone control.
	1E–1EL–(1–85–3)	For ships with or without zone control.
	3S–4L–(2–112–3)	(1) First section of a feeder with more than one section.
Main	(3–125–2)—1L–B	NOTE: No remarks are given for Main, Submain, Branch, and Subbranch components as they have been explained singly already in table 3.
	(1–85–3)—1EL–D	
	(5–52–4)—28SP–C	
Submain	(3–125–2)—1L–B1	
	(2–142–1)—1L–A	
	(1–85–3)—1EL–D1	
	(5–52–4)—28SP–C1	
Branch	(3–125–2)—1L–B1A	
	(2–142–1)—1L–A2	
Subbranch	(2–142–1)—1L–A2B	

TABLE 3.—TYPICAL POWER AND LIGHTING CABLE DESIGNATIONS

Component	Meaning
6SG	Ship's service generator supplying ship's service switchboard No. 6S.
6SGA	Ship's service generator A (where 2 or more are used) supplying ship's service switchboard No. 6S.
1EG	Emergency generator supplying emergency switch board No. 1E.
2SFG	Special frequency generator supplying special frequency switchboard No. 2SF.
6S	Ship's service switchboard No. 6.
1E	Emergency switchboard No. 1.
2SF	Special frequency switchboard No. 2.
3SB	Section B of ship's service switchboard No. 3S.
31	No. 1 load center switchboard in zone 3.
4P	450-volt ship's service power.
10SP	1,000-volt special frequency power.
4EP	450-volt emergency power.
1EL	120-volt emergency lighting.
4L	450-volt ship's service lighting.
1L	120-volt ship's service lighting.
28SP	28-volt special frequency power.
(3–125–2)	Distribution panel located on 3d deck, frame 125, port side of centerline.
(2–112–3) (1)	Section one of cable connected to distribution panel located on 2d deck, frame 112, second one outboard of the centerline on the starboard side.
B	No. 2 feeder, main, or submain supplied from load center, switchboard or distribution panel.
B1	No. 1 submain or branch supplied from distribution panel or distribution box.
B1A	No. 1 branch or subbranch supplied from distribution box.
B1A2	No. 2 subbranch supplied from distribution box.

Special Equipment Systems

All special equipment systems cable such as Degaussing, Electronics, Casualty Power, etc., are designated in accordance with table 1 after they leave the supply and control panels. There are so many special suffixing designations for such cables that no attempt has been made to include them in this text.

Phase Markings and Tag Color Coding

The phase and polarity markings and the tag color coding for Vital, Semivital and Nonvital circuits are the same as the 1949 designations.

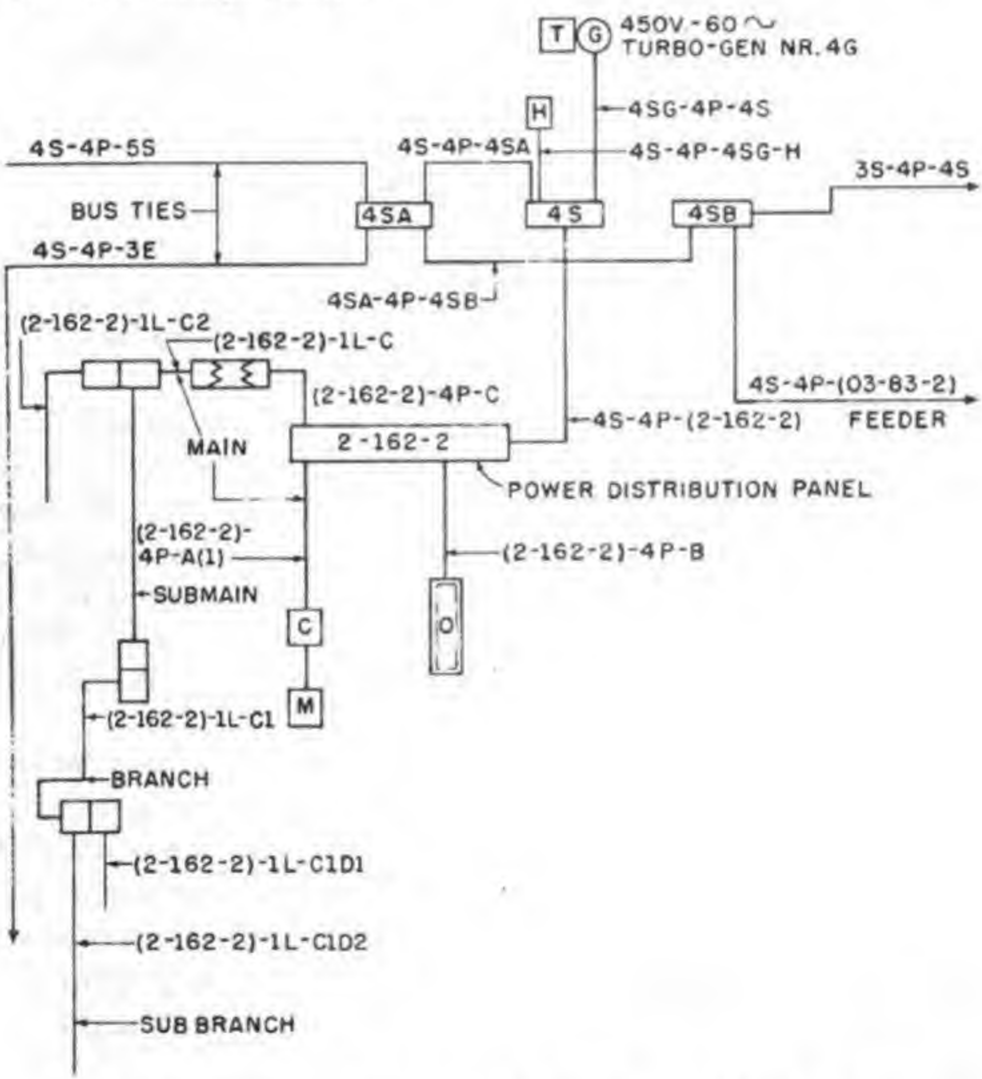


Figure 9-4.—Typical designation of power and lighting system.

ELEMENTARY WIRING DRAWINGS

The elementary wiring drawing is, as the name implies, as simple as possible while still showing necessary details. It shows each individual conductor in the circuit and every connection made. It may or may not show the connection boxes themselves. Normally these prints show identifying markings with which the cable can be physically located. Elementary drawings, in most instances, do not show fixture locations and cable runs, unless specifically concerned with one equipment system. They are not drawn to scale. An elementary drawing would be used to check proper connection in a circuit or to make the initial wiring hookup. Each equipment elementary wiring blueprint contains one circuit only. Figures 9–3 and 9–4 illustrate an electrical system elementary blueprint.

ISOMETRIC WIRING DRAWINGS

Each electrical system has its own isometric wiring drawing. If the individual system is not too large, it will be covered by one blueprint. There will be a separate isometric wiring diagram for each IC circuit.

In isometric wiring drawings the decks are arranged in tiers, starting at the bottom with the hold and successively arranged to show the bridges and superstructure. Section and divisional bulkheads are shown, as well as the bulkheads that divide the deck into the main compartments. The centerline is marked with frame numbers every 5 or 10 frames. The outer edge of each deck is drawn with the general outline of the shape of the ship.

All athwartship lines are shown at an angle of 60° to the centerline, and the location of compartments as shown by the blueprint gives an accurate idea of the deck arrangement, although not in detail. The purpose of distorting the athwartship lines is to permit the continuous representation of cables passing between decks. Cables running from one deck to another are drawn as light lines at right angles to the centerline.

The exact location of fixtures and cable runs cannot be

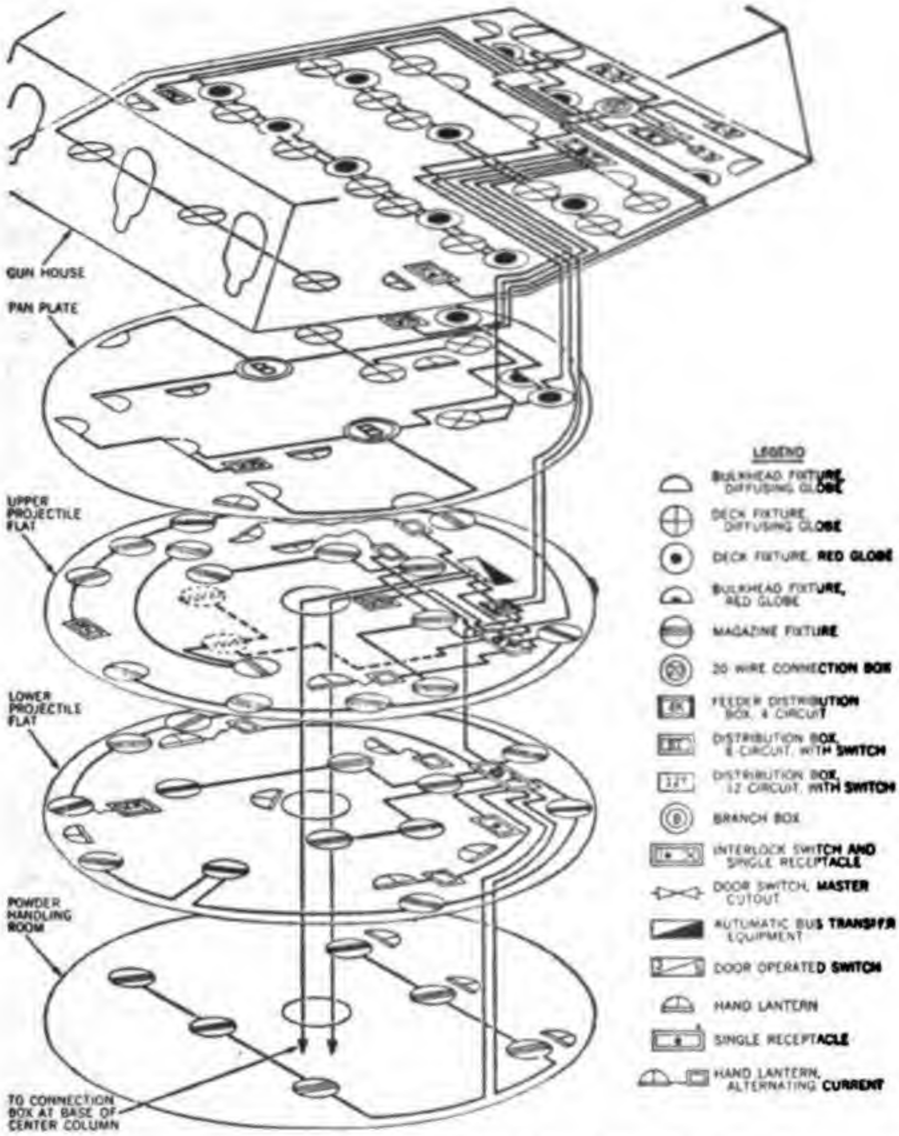


Figure 9–5.—Isometric wiring diagram for 8-inch turret illumination system.

satisfactorily found by use of an isometric wiring blueprint, because the locations shown are only approximate. The symbol numbers of the fixtures in the circuit are given and also the cable numbers and sizes. This aids the electrician in associating each circuit with its elementary wiring drawing. An isometric wiring diagram for a turret is shown in figure 9–5.

Elementary and isometric presentations of a circuit often are on the same blueprint. Isometric wiring drawings use

schematic symbols and are never drawn to any one fixed scale.

A cable, regardless of the number of conductors, is represented on an isometric wiring diagram by a single line, and no attempt is made to show the proper connections in connection boxes or at fixtures. An isometric type of drawing thus shows at a glance a rough picture of the entire circuit's layout. Isometric wiring diagrams of lighting and power circuits usually are used to indicate only the main supply cables, feeders, and their associated equipment.

WIRING PLANS

There are many types of wiring plans, each depending on the type of installation concerned. A wiring deck plan is a blueprint used chiefly in construction. It enables a naval shipyard electrician to lay out his work for a number of cables without referring to each individual isometric wiring drawing. It would be used by the shipboard electrician to trace a circuit or circuits on one deck.

The wiring plan for a specified piece of equipment would show all the wires used and where they are connected, such as shown by the illustration in figure 9–6.

SCHEMATICS

A schematic diagram shows how the parts of a circuit are connected for the OPERATION of the electrical or electronic circuit. It does not tell how the parts look nor how they are physically constructed. Each component is illustrated by a symbol and once these symbols are learned you will find the electrical schematics much easier to read. Figure 9–7 illustrates a layout wiring diagram with a schematic diagram of the same circuit.

WIRING CONNECTIONS

In schematics and in some wiring diagrams, there must be an indication where wires cross as to whether the wires are connected or merely crossing. There are two methods

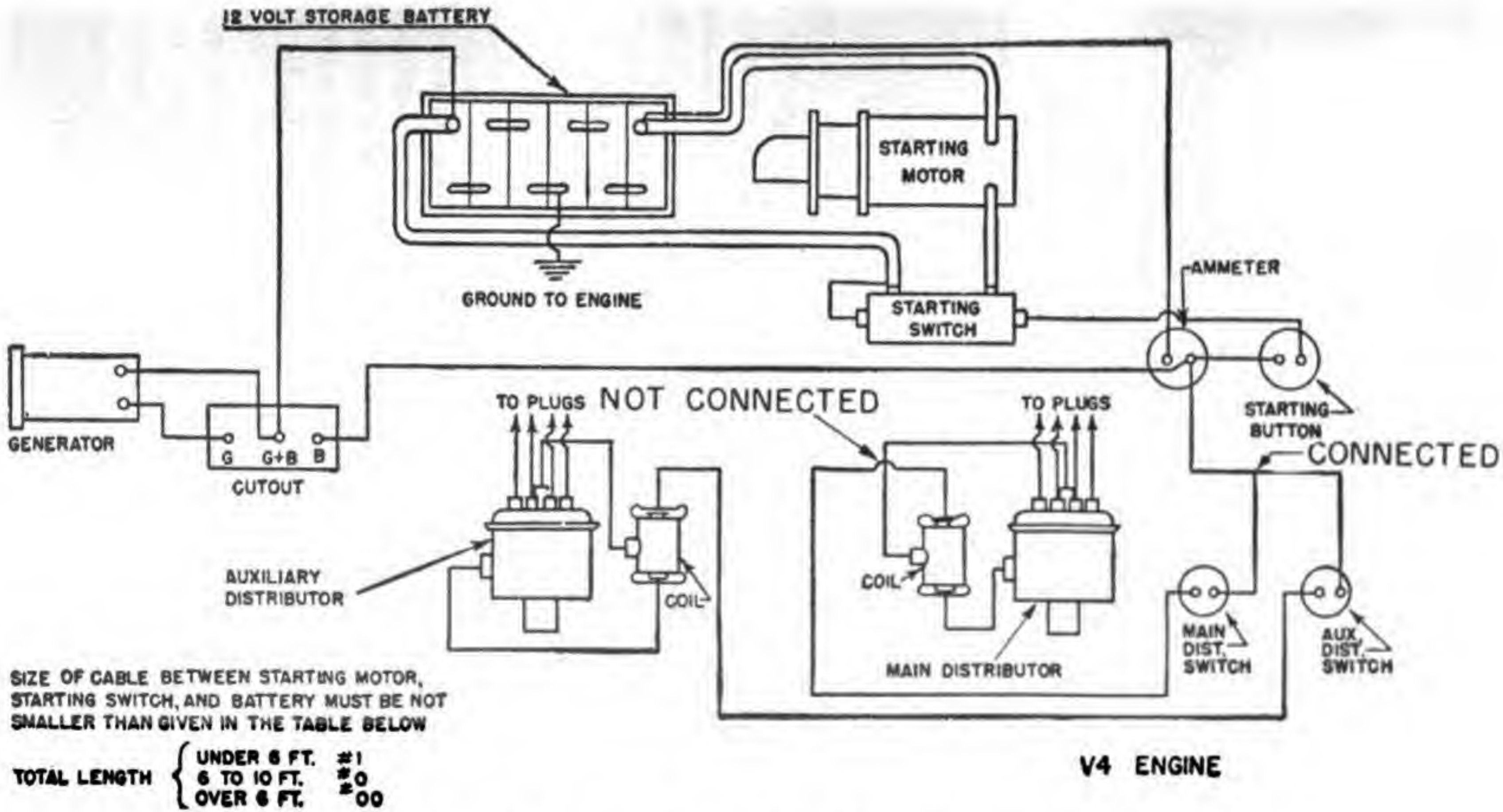


Figure 9–6.—Wiring diagram for V4 powerboat engine.

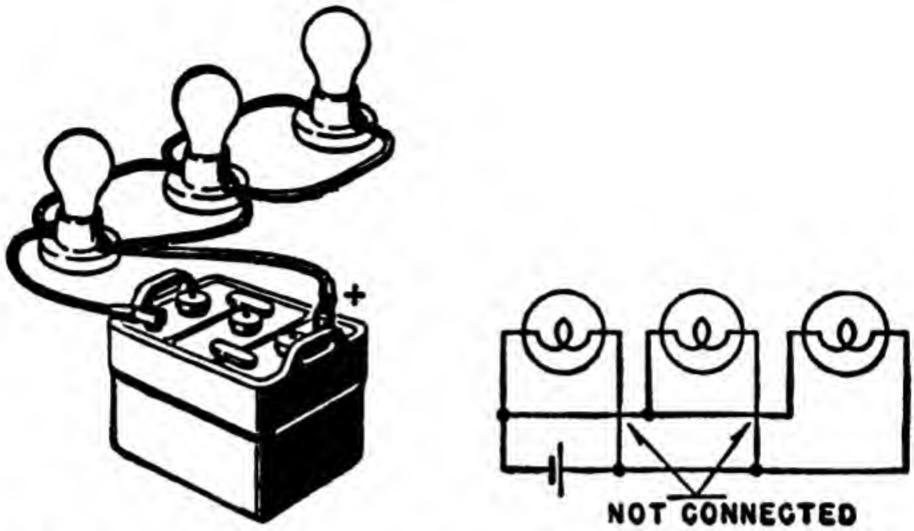


Figure 9–7.—Simple circuit diagram showing layout and schematic presentation.

of making this indication. In figure 9–6 one method is shown wherein crossing wires are indicated by a half circle or loop in one of the wires and connecting wires are shown by each wire being straight at the junction. In figure 9–7 (schematic) the second method is shown wherein crossing wires are shown as straight lines at the junction point and connecting wires are shown at the junction with a large black dot. The second method is now preferred although many instruction books and blueprints still contain the first method.

SUMMARY

This chapter has pointed out the two systems of electrical markings used in ships of the Navy. A brief description has been given of each system (new and old). For further reference and more details the reader is referred to section 528–2 of the *General Specifications for Ships of the U. S. Navy*.

This chapter has also explained the differences in the various types of electrical blueprints, the elementary, isometric, wiring layout and schematic and given the specific uses of each. Standard symbols for these prints are promulgated in the Military Standard Pamphlets (Mil-Std).

Know your blueprints and how to use them for fast and efficient maintenance.

QUIZ

1. What are the two basic reasons for having more than one type of blueprint?
2. What are the four basic types of electrical blueprints?
3. Why must we have standard symbols and reference designations for use in electrical and electronic blueprints?
4. How are the identifying location numbers for electrical units assigned aboard ship?
5. The letters _____, _____ and _____ are used to identify the phases in a three-phase electrical circuit.
6. Power and lighting cables and circuits are classified into, _____, _____ and _____ groups according to their importance and are identified respectively by the following colored cable tags: _______, __________, and __________.
7. How do the identifying numbers differ for the feeders emanating from the forward and after switchboards?
8. Why was it found necessary to develop a new electrical equipment designation system which would be an improvement over the 1949 system?
9. The __________ wiring drawing shows each individual conductor in the circuit and every connection made.
10. The __________ diagram's purpose is to show connections for operation of the electrical or electronic circuit.
11. The __________ __________ __________ is a blueprint used chiefly in construction work.

CHAPTER 10

MECHANICAL AND PIPING SYMBOLS

Although this chapter mentions, from time to time, several of the many Navy ratings by name, the information given throughout the chapter probably concerns all the ratings. It is natural that you will be mostly interested in your own rating. But remember that you may be assigned to a damage control party. On that job for example, piping systems for drainage and flooding, refrigeration, boiler water, or possibly fuel oil—might well be your main interest for some time. In that case many parts of the chapter will be very important to you. Therefore, as you study page after page keep in mind the fact that it was written for all ratings and that it has much to offer you as well as the other fellow. Many pages are devoted to reference material such as an alphabetical list of symbols by name. This will serve as a reference as you cannot possibly remember all of them. Try to remember a few and then look up others when you find them appearing on the blueprints you need for the jobs you have to do.

FLOW DIAGRAMS

Fire Control Technicians, Gunner's Mates, and Torpedomen often have to read both flow diagrams and mechanical schematic diagrams with symbols. First let's look at the simpler form such as the flow diagram shown in figure 10–1. This diagram uses sketches of the actual components instead of the symbols we will study later. It is possible and better to use this type of diagram when the gear being studied is not too complicated, when there are not too many components

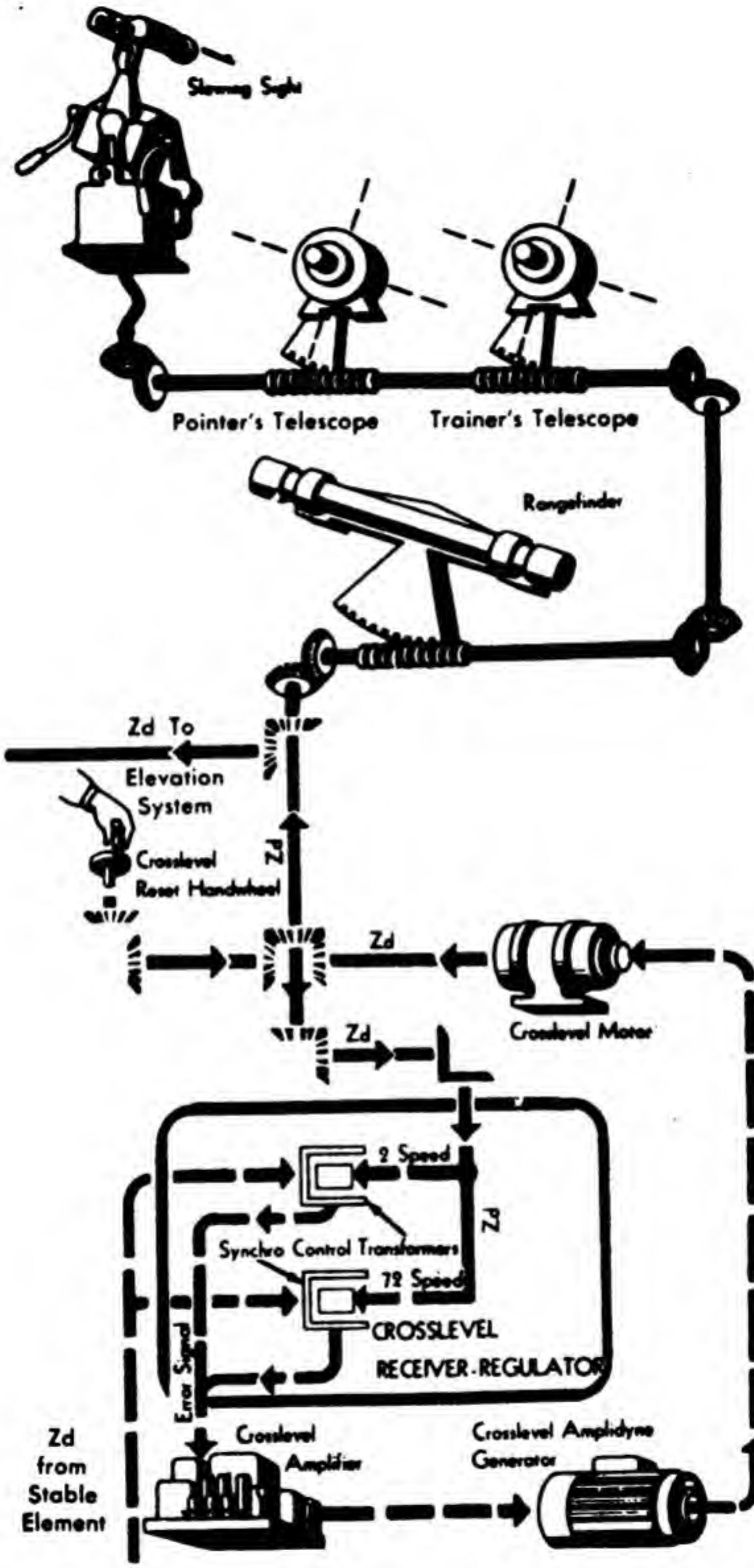


Figure 10–1.—Flow diagram of cross-level control system.

(individual pieces of gear) to be shown, and when it is thought the reader will understand simple pictures better than he will symbols.

Starting at the top of figure 10–1, see the slewing sight. It actually looks like a slewing sight aboard ship, even to the line of sight you see projecting from one of the lenses. Below the slewing sight you see bevel gears which transmit rotation from one shaft "around the corner" to a shaft with the two worm gears which mesh with the quadrants on the pointer's telescope and the trainer's telescope. Similarly you can follow the shafts down the flow diagram through bevel gears to the rangefinder worm and quadrant and to the point where you see bevel gears on a shaft labeled *Zd To Elevation System*. You can understand everything so far simply by following the pictures. Now when you get to the Cross-level Motor, you will notice broken lines at one end and solid lines at the other. The broken lines indicate that ELECTRICAL energy is transmitted to the motor from the generator and is transformed into MECHANICAL energy by the motor to turn the shafts represented by solid lines. Knowing this, you can follow through the rest of this flow diagram on your own. One further point is the fact that the solid line around the Synchro Control Transformers and their included shafting and electrical cables is there to identify the area of this diagram which represents (as it is labeled) the Cross-level Receiver-Regulator.

MECHANICAL SCHEMATIC DIAGRAMS

You will have to read mechanical schematic diagrams more often than you will the simpler flow diagrams like the one shown in figure 10–1. The purpose of mechanical schematics is to show how certain standard mechanical units are "hooked together" or mechanically interconnected. Thus, the lines on this type of drawing, as shown in figure 10–2, indicate shafts running from one piece of gear to another. The lines are labeled *cR*, *Xt*, and so forth and an FT must and will know what the labels mean. You see several circles with an *X* in the center. Each of these is a DIFFERENTIAL GEAR and has

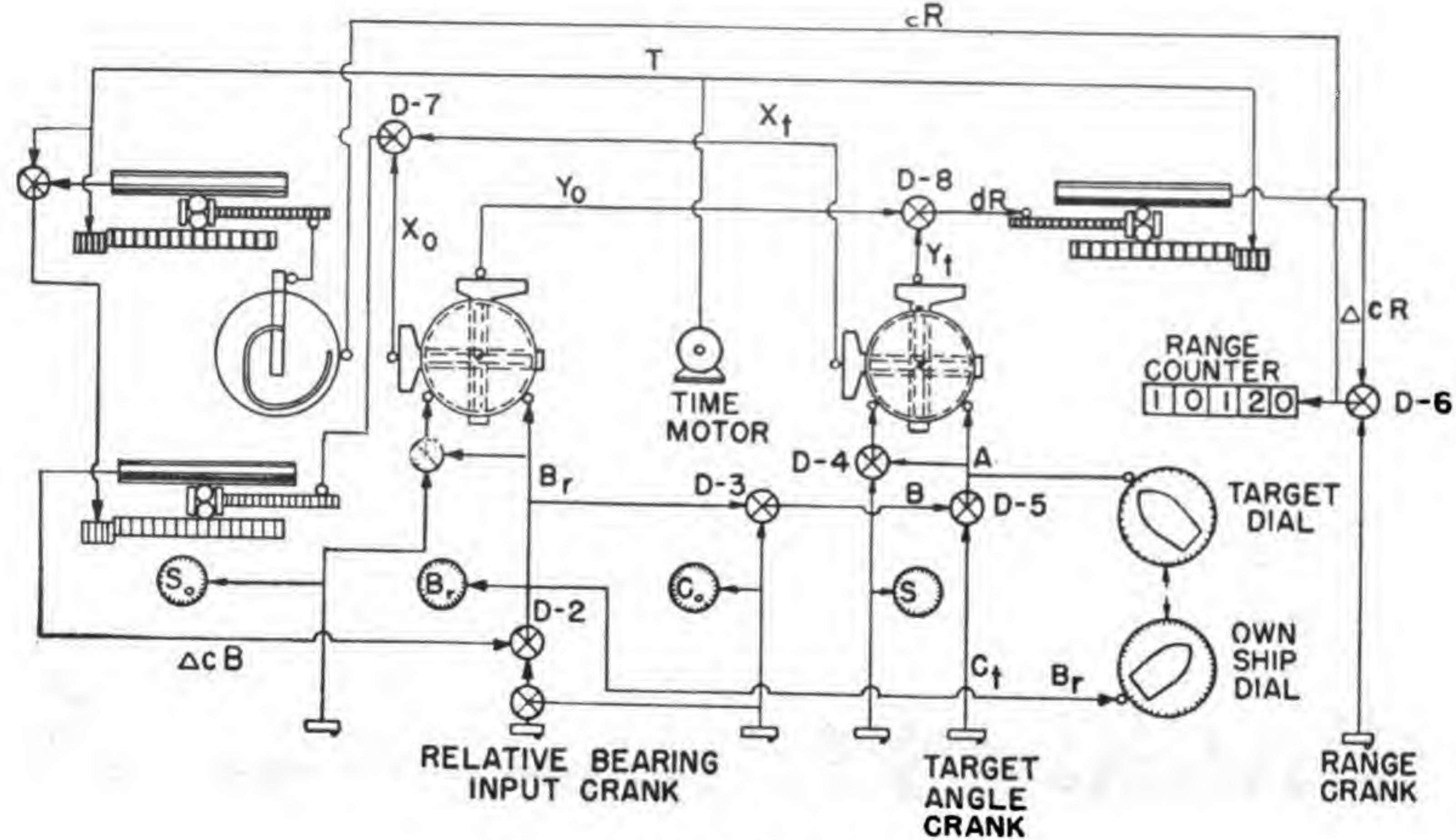


Figure 10-2.—A simple rangekeeper.

two input shafts and one output shaft. See the arrowheads which tell you which are which. The arrowhead will point in the direction of the flow of mechanical energy through the unit. The two identical pieces of gear at the left, and the one in the upper right-hand corner, are INTEGRATORS. On the top side of each you see a long roller. On the bottom are a small and a large gear. When you see this combination used in a mechanical schematic you know you are looking at an integrator.

Likewise, when you see a symbol like that one at the left side of the figure, between the two integrators, you are looking at the symbol for a computing cam. Immediately to the right you see a component solver; then a time motor is so labeled. Another component solver, and a range counter which is labeled are other easily recognized components. Other differential gears, diagramed as a circle with an *X* in the center as explained previously, appear in figure 10–2. In the lower right-hand corner you see, labeled, the TARGET DIAL and the OWN SHIP DIAL. Also shown are four smaller dials extending to the left across the diagram, each labeled by symbols as to its function. Lastly, across the bottom of the diagram are six cranks. Three of them are labeled and all six of them show you what the symbol for a crank looks like, complete with handle or knob. A Fire Control Technician, or anyone else concerned with mechanical schematics, will encounter many diagrams similar to this one in studying about the equipment he will operate, service and maintain. In conjunction with the electrical circuit "prints," these are the blueprints of his job. He must simply learn the symbols for the various kinds of inputs and outputs, and for the various kinds of components of his equipment—and then "follow the prints" to learn what his job is and how to do it.

PIPING SYSTEMS

If you played basketball or football in school, you used schematic diagrams. The coach drew the diagrams. He showed the location of the players' positions by small

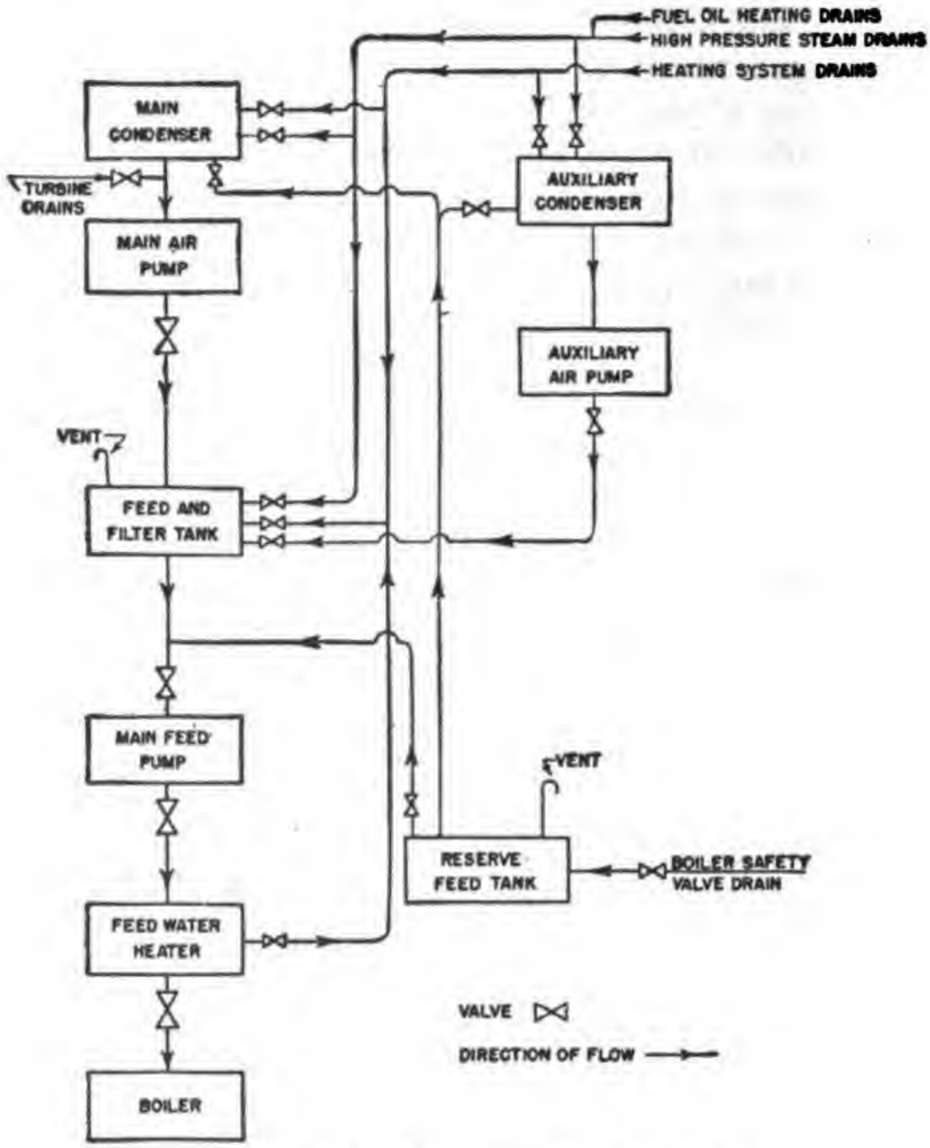


Figure 10–3.—Open feedwater system for boilers.

circles and their movements by lines and arrows. The draftsman uses similar diagrams to show the ship's fresh water system, lubrication systems, fuel oil systems, refrigeration system, and drainage systems.

The secret of using these schematic diagrams is knowing and recognizing the symbols. Most of these symbols are standardized. If any unusual symbols are found on the diagram, you'll find an explanation in the legend, which is an explanatory reference table or block.

DIAGRAMS

Study the diagrams, figures 10–3, 10–4, 10–5, and 10–6. Don't be disappointed if the lines in the diagram don't look exactly like pipes. If they did, it would be a mechanical drawing and not a diagram. The diagram will clearly indicate the locations of valves, vents, gages, tanks, pumps, etc. It will show the direction of flow of the liquid or steam in the pipes and tell what kind of substance it is.

Immediately following these diagrams is a table containing some of the more common symbols used in diagrams of military equipment. Refer to them while studying the diagrams.

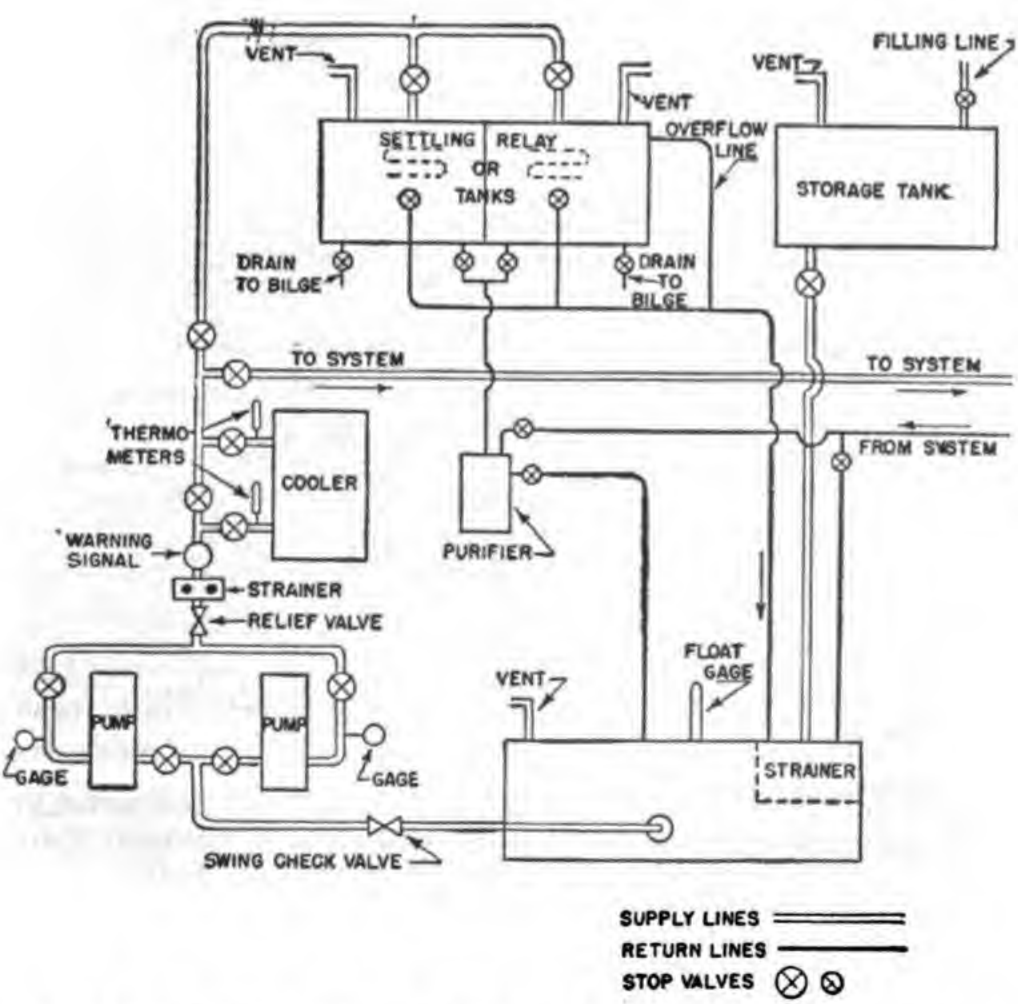


Figure 10–4.—Typical forced lubrication system found on naval vessels.

MECHANICAL SYMBOLS FOR GENERAL USE

The following pages show many symbols for general use. Most of them are piping symbols, but there are also mechanical and power symbols as well as aeronautical symbols.

The use of symbols is the only way in which it is possible to include in a drawing the great mass of complex piping, wiring, and mechanisms that make up the many different kinds of gear used by the Navy. A schematic drawing does a special job in "picturing" an equipment, or part of one, but as a general rule you will work from drawings with symbols.

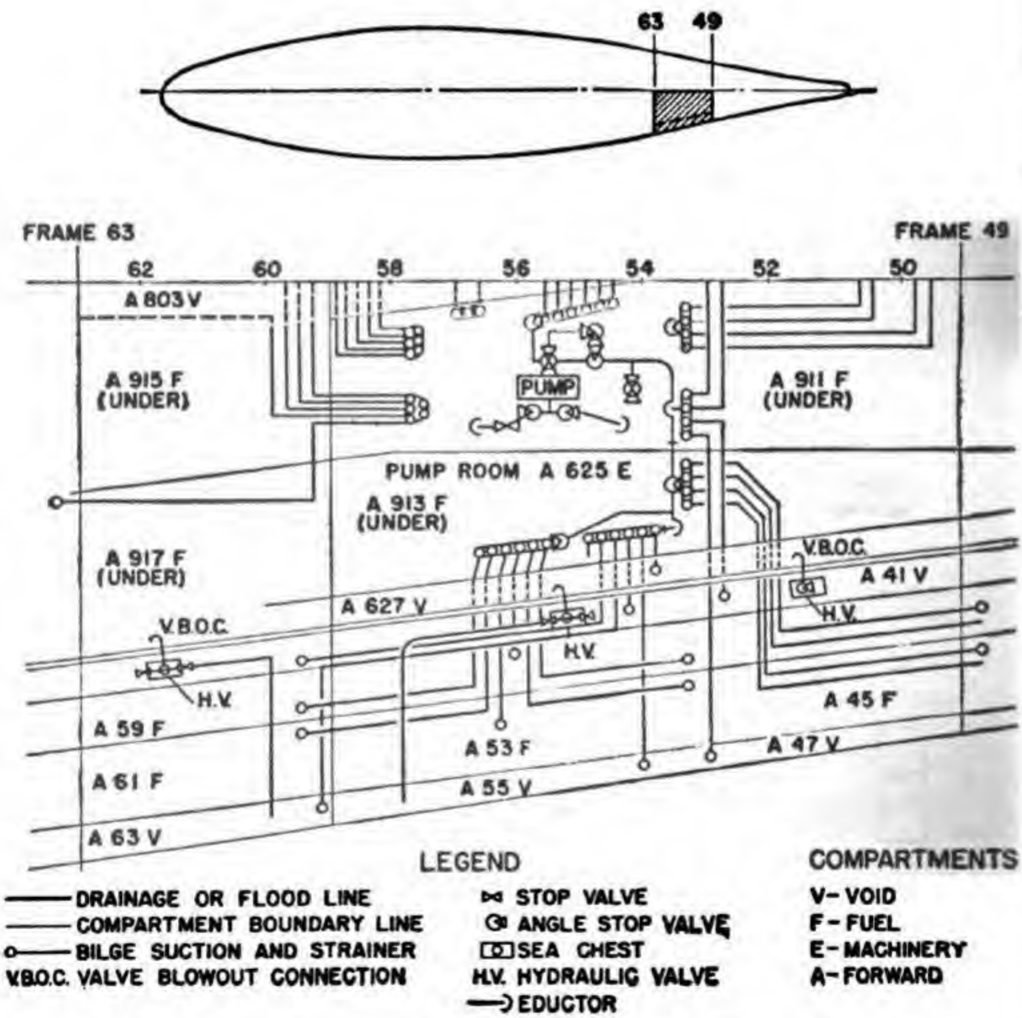


Figure 10–5.—Detailed sketch of drainage and flooding system. *North Carolina* class battleships.

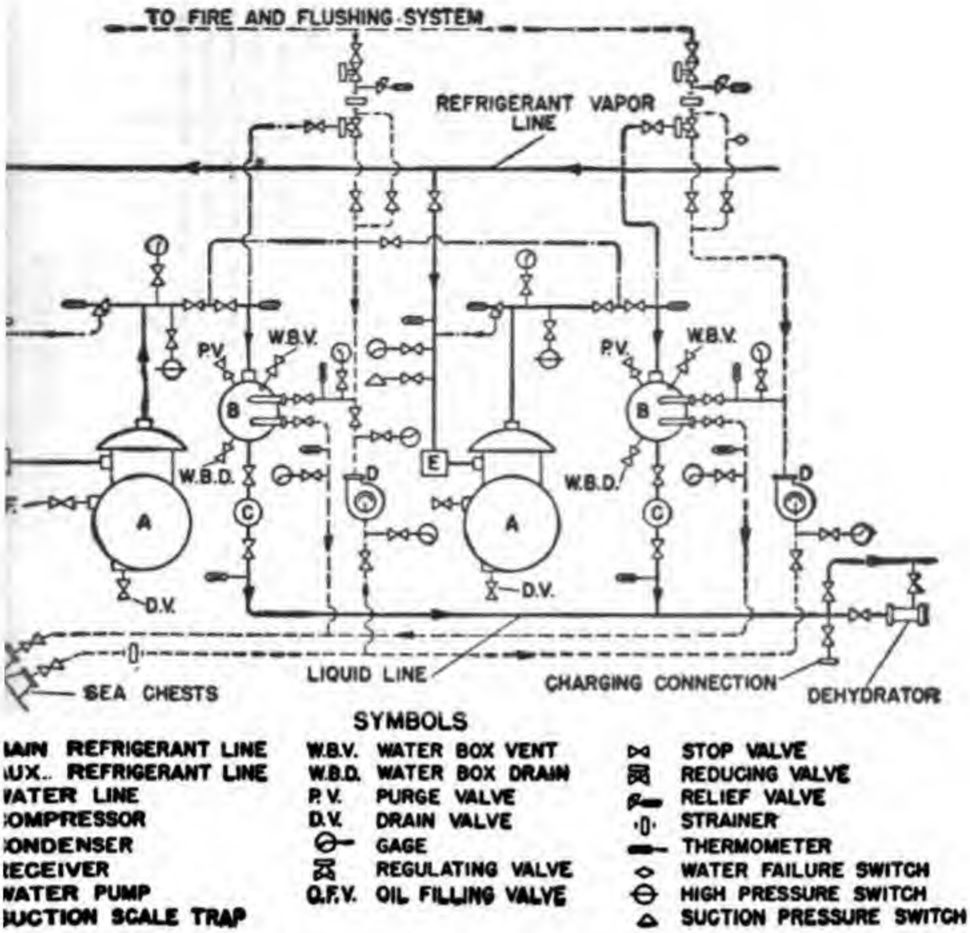


Figure 10–6.—Diagram of ship refrigeration system.

These symbols are standardized so that the same ones are used wherever Navy drawings are made. The standard symbols shown here are from MIL-STD-17, 6 July 50, which is currently the latest and most up-to-date information. From time to time new Military Standards are issued, and new symbols can be expected, but once a symbol has been in use over a period of years, chances are that it will be retained.

You can't possibly sit down and memorize all the symbols, and that isn't necessary. Continued use will familiarize you with those you need to know with little or no extra effort on your part. You "use" symbols when you read a drawing as well as when you make one.

PIPING SYMBOLS

1. Designation of relative importance of piping systems

Principal system

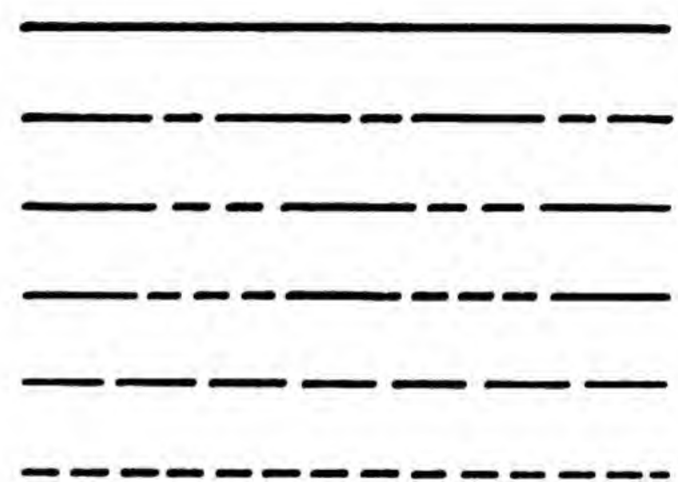
Second system in importance

Third system in importance

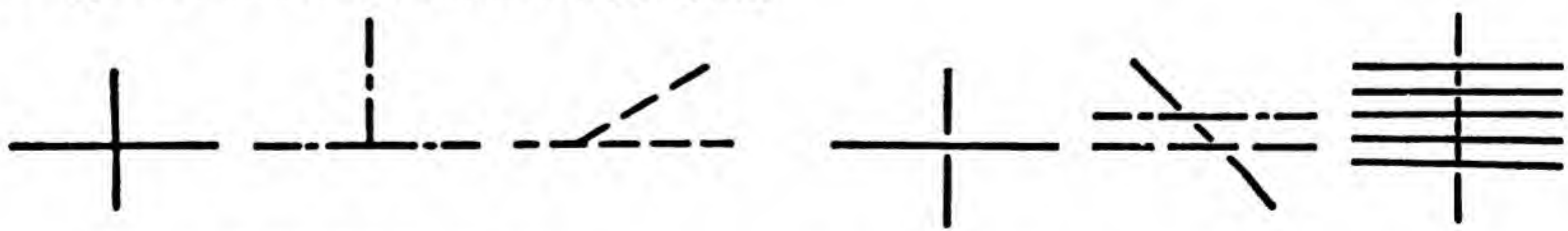
Fourth system in importance

Fifth system in importance

Invisible lines (adequately labeled as to system)



2. Typical intersections and crossovers of piping lines

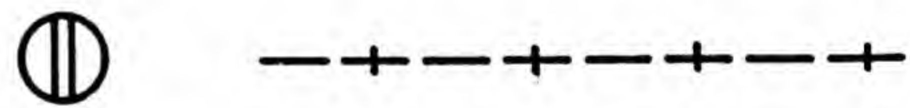


Typical intersections

3. Detail labeling of piping lines on drawings

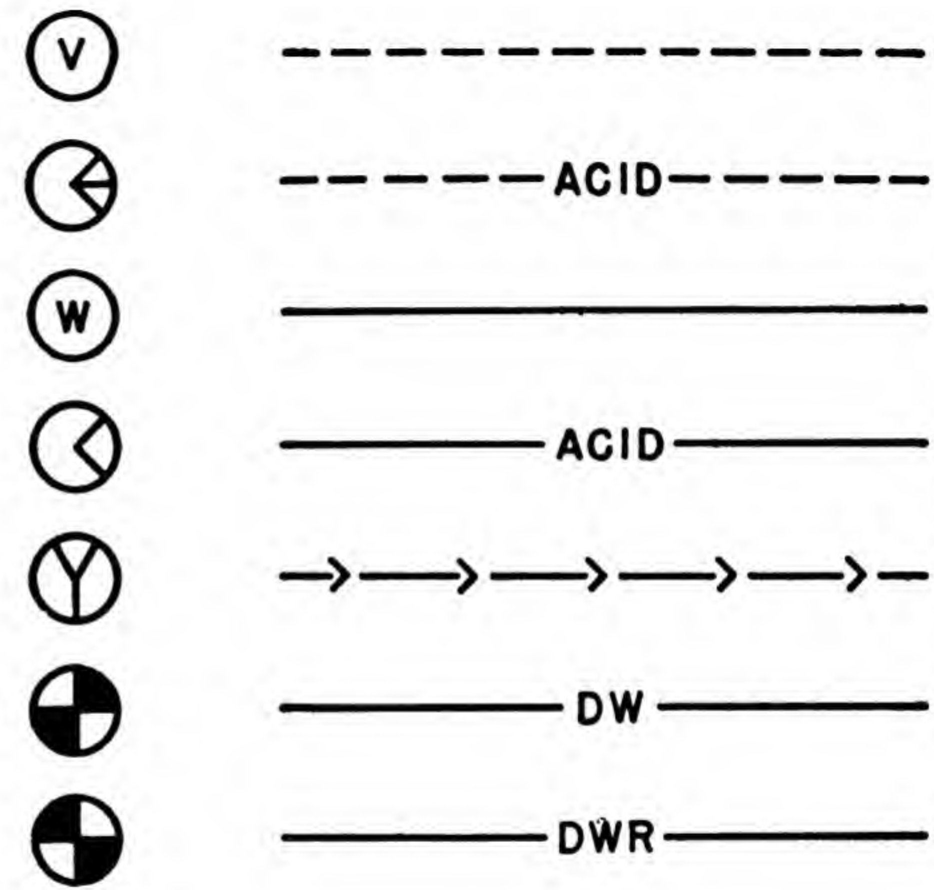
Service	*Riser or stack*	*Symbol*
Acetylene	AC	AC
Air, compressed	A	A
Drain, building*	D	
Drain, storm or roof		
Drain, subsoil		
Fuel supply (except gasoline)	F	FUEL
Gas	G	G

*Above or below grade.

Gasoline	
Hydrogen	
Oxygen	
Sewer, sanitary*	
Sewerage, combined	
Soil*	
Vacuum	

*Above or below grade.

Vent	
Vent, acid	
Waste *	
Waste, acid or chemical	
Waste, indirect	
Water, chilled drinking	
Water, chilled drinking return	



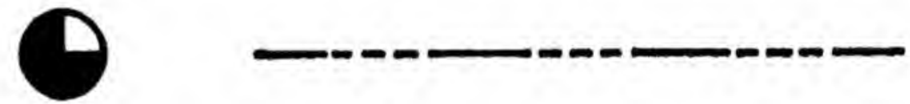
*Above or below grade.

Water, cold

Water, fresh

Water, hot

Water, hot return



Water, raw

Water, salt

Water, tempered

Tube runs, pneumatic

Carbon dioxide system

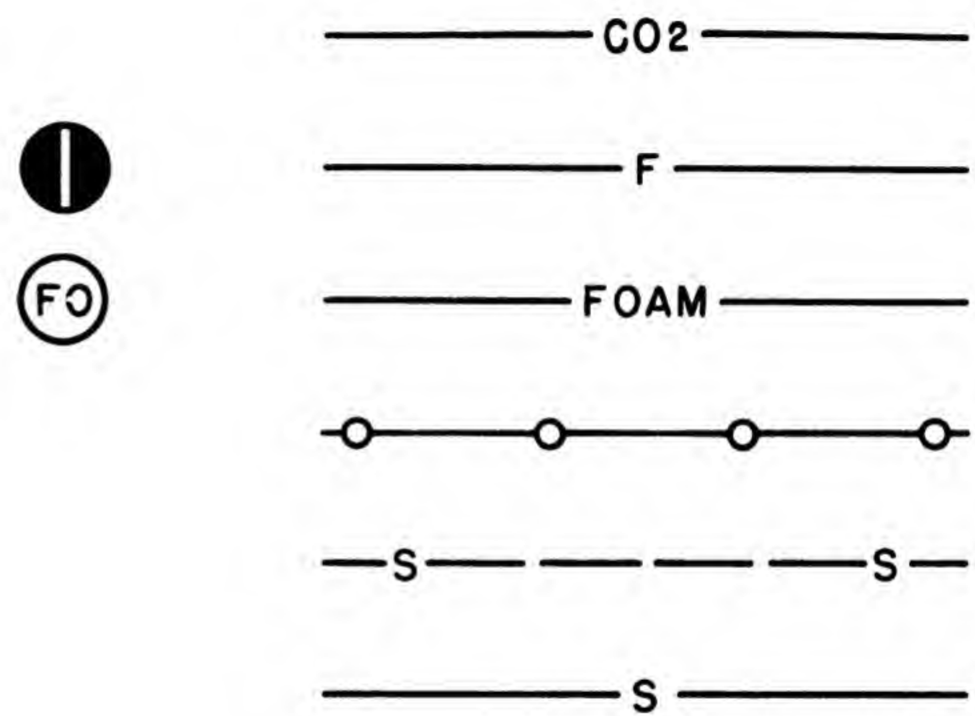
Fire line

Foam solution

Sprinkler branch and head

Sprinkler drain

Sprinkler main supply



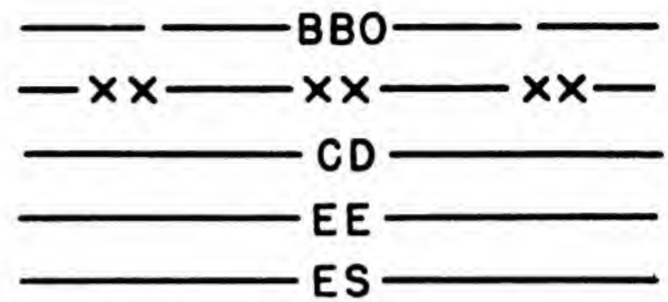
Boiler blow-off

Capillary tubing

Condensate

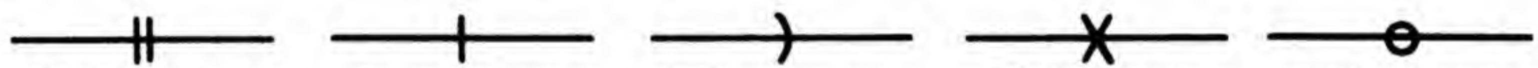
Exhaust

Exhaust, steam



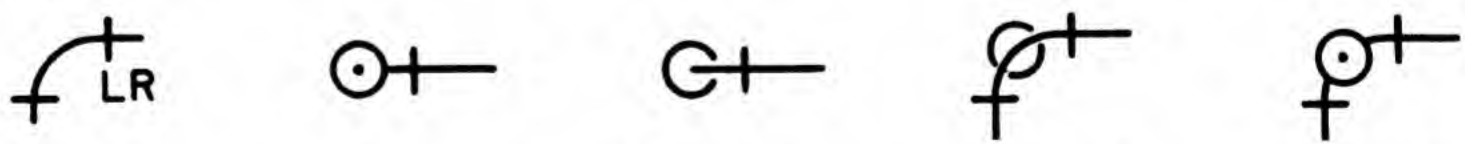
4. Common piping symbols

Joints

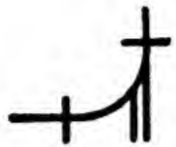


Flanged ends | Screwed ends | Bell-and-spigot ends | Welded and brazed ends | Soldered ends

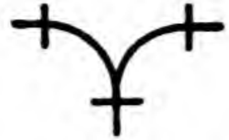
Elbows



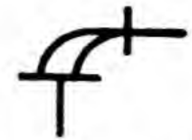
Elbow, long radius | Elbow, turned up | Elbow, turned down | Elbow, side outlet, outlet down | Elbow, side outlet, outlet up



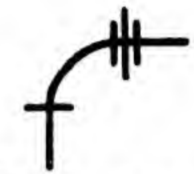
Elbow, base



Elbow, double branch, or plain double T–Y

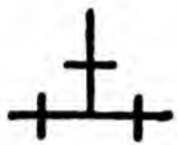


Elbow, reducing



Elbow, union

TEES

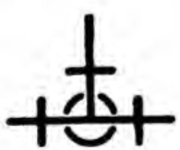


Tee

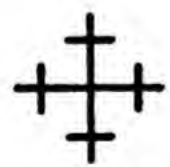
Tee, outlet up

Tee, outlet down

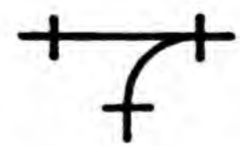
Tee, side outlet, outlet up



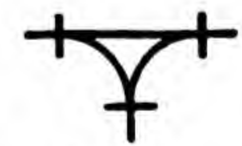
Tee, side outlet, outlet down



Cross

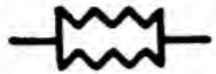


Tee, single sweep, or plain T–Y



Tee, double sweep

EXPANSION JOINTS


Expansion joint, bellows


Expansion joint, sliding

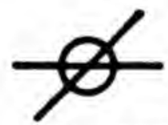
BEND AND SLEEVE


Return bend


Sleeve

VALVES


General symbol


General symbol, check


Angle

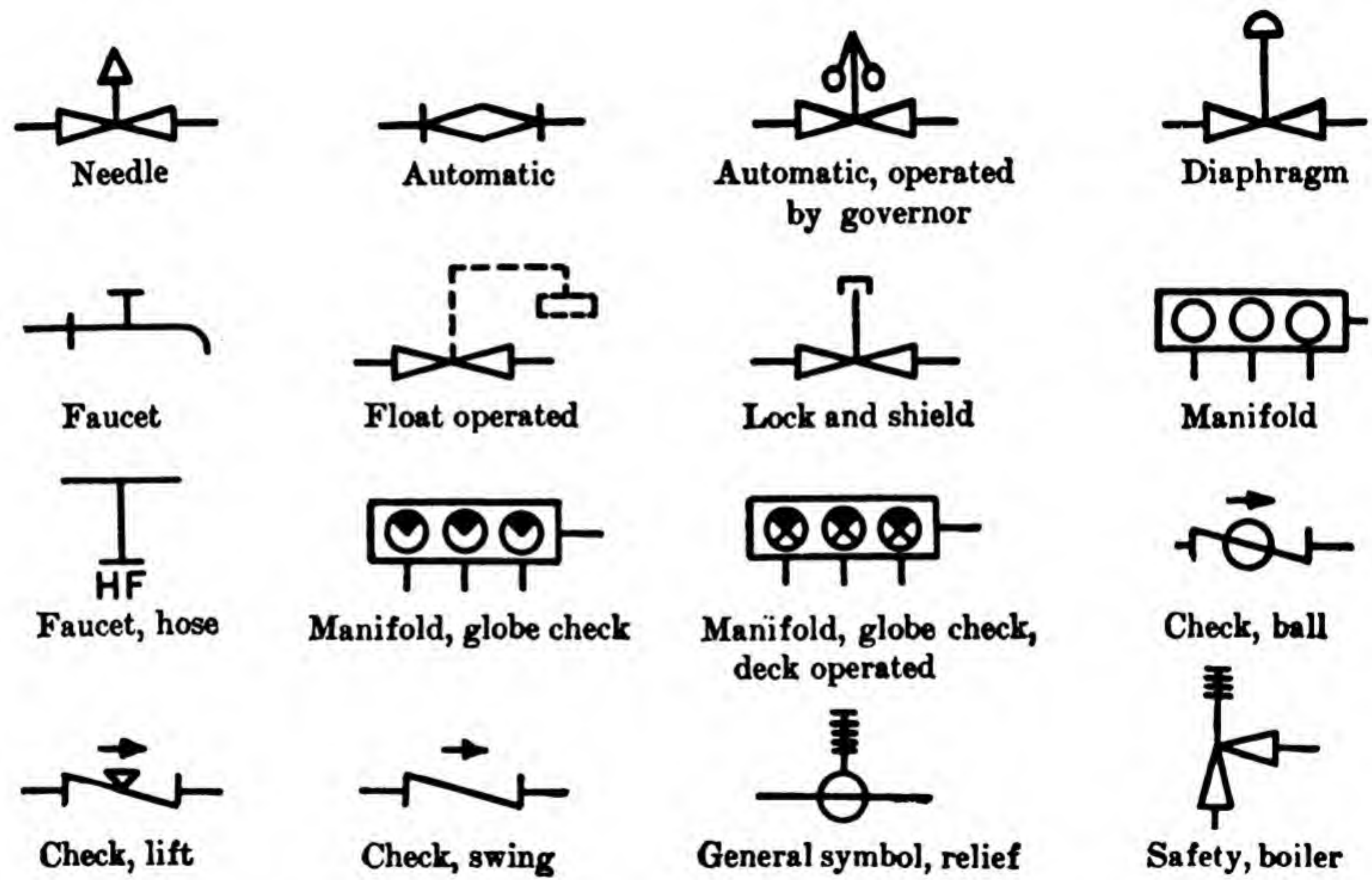
Angle, hydraulically operated


Cross


Gate


Globe


Globe, locked closed

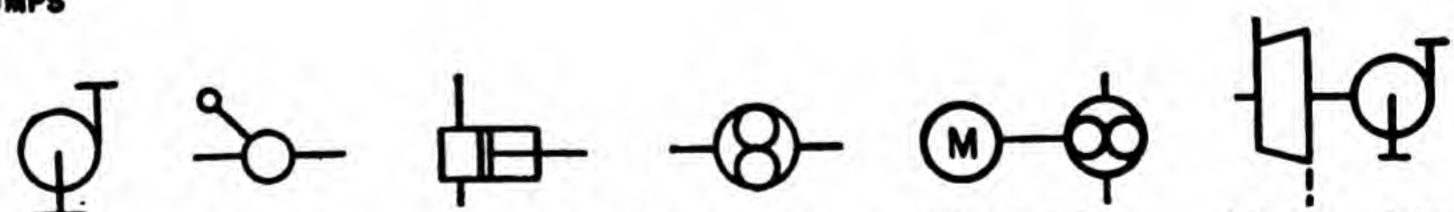

Needle
Automatic
Automatic, operated by governor
Diaphragm
Faucet
Float operated
Lock and shield
Manifold
Faucet, hose
HF
Manifold, globe check
Manifold, globe check, deck operated
Check, ball
Check, lift
Check, swing
General symbol, relief
Safety, boiler

Proportioning, three-way | Pump governor | Solenoid control | Thermostatically controlled

VALVE JOINTS

Flanged ends | Screwed ends | Bell-and-spigot ends | Welded and brazed ends | Soldered ends

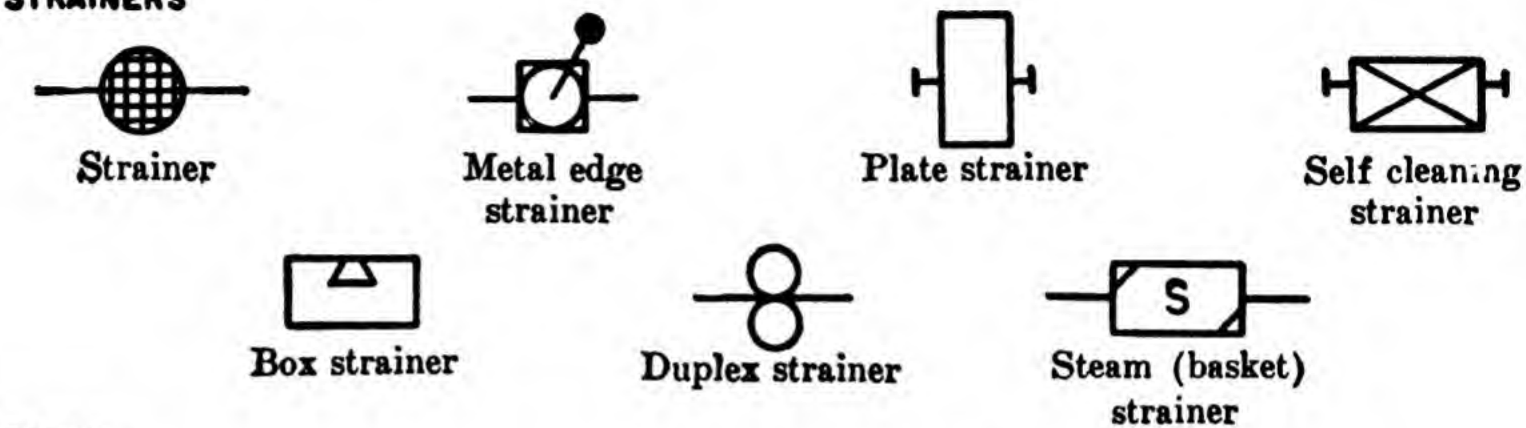
PUMPS



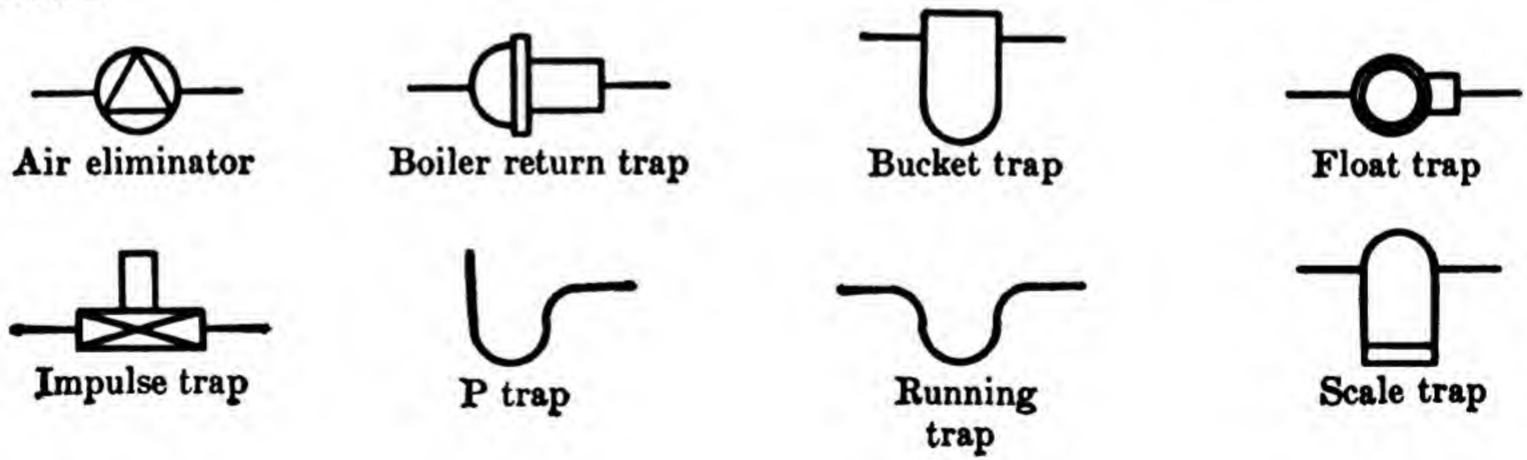
Pump, centrifugal | Pump, hand | Pump, recip-rocating | Pump, rotary and screw | Motor driven rotary pump | Turbine driven centrifugal pump

5. Strainers, traps, and drains

STRAINERS



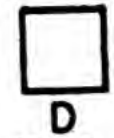
TRAPS



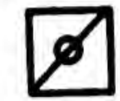
373024 O—56——11

Thermostatic
blast trap

Thermostatic
trap



Drain



Drain, deck,
with valve

6. Tanks, sea chests, and eductor

TANKS

Tank, open

Tank, closed

SEA CHESTS

Sea chest, discharge

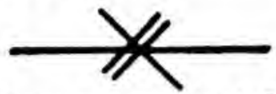
Sea chest, suction

EDUCTOR

Eductor

7. Ductwork for ventilation

CLOSURES

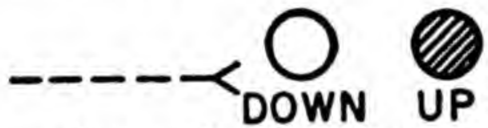


Closure, watertight, horizontal

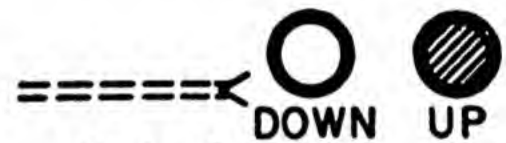
Closure, watertight, vertical

Damper

EXHAUST SYSTEMS



Duct, exhaust system, nonwatertight



Duct, exhaust system, watertight

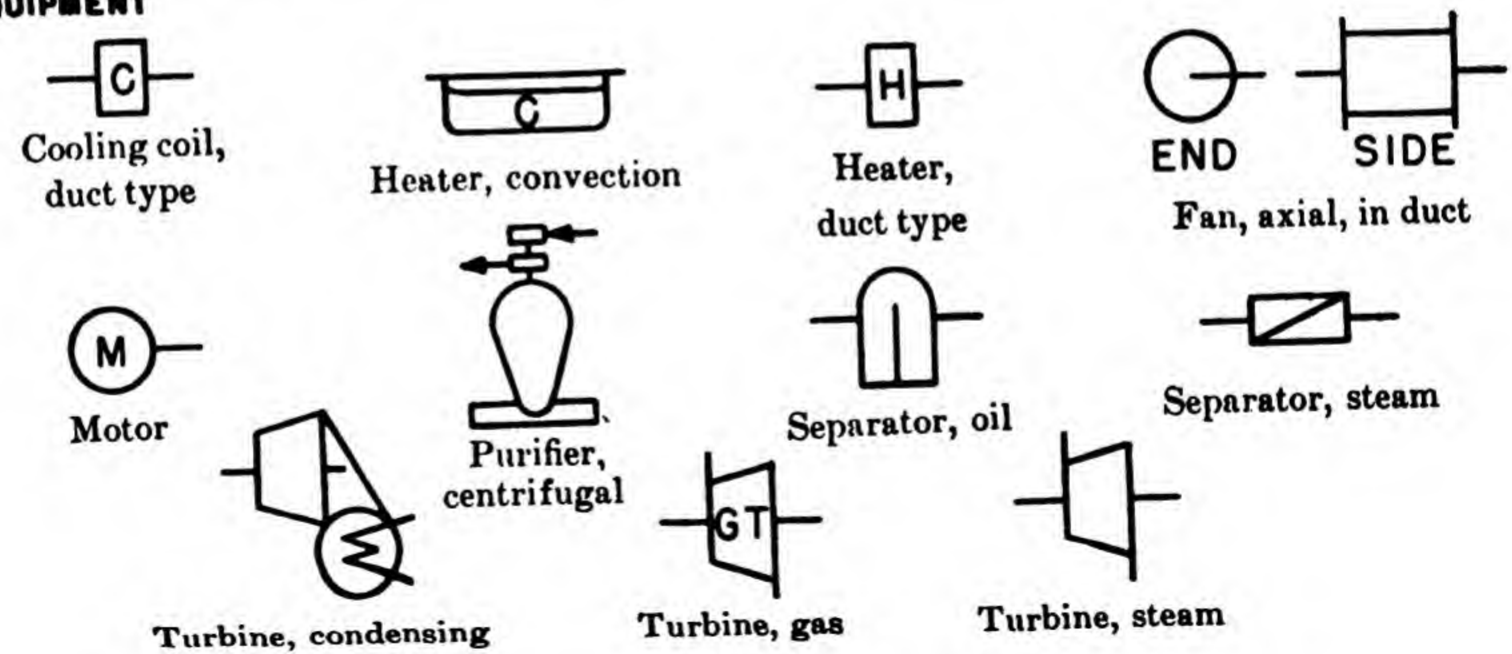
RECIRCULATING SYSTEMS

Duct, recirculating system, nonwatertight

Duct, recirculating system, watertight

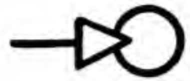
SUPPLY SYSTEMS

EQUIPMENT

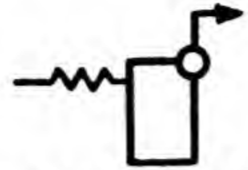


MECHANICAL AND POWER SYMBOLS

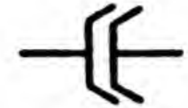
Blower



Blower, soot

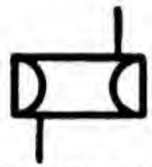


Boiler, steam generator (with economizer)



Clutch, all types

Combustion chamber, gas turbine



Compressor, rotary, blower vane type roots

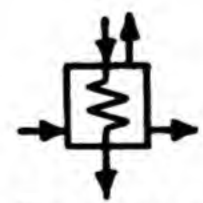
Condenser, surface

Duplex oil filter

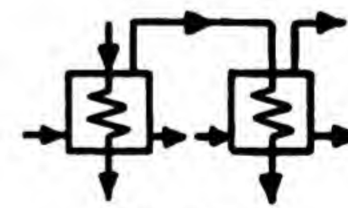
Engine, diesel

Engine, gas

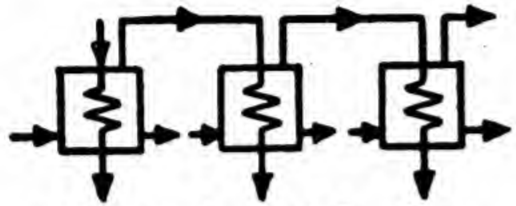
Engine, steam



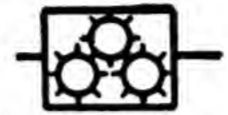
Evaporator, single effect



Evaporator, double effect



Evaporator, triple effect



Gear train, all types

Meter, area type (other than electrical)

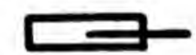
Meter, displacement type (other than electrical)

GAGES

Pressure

Vacuum

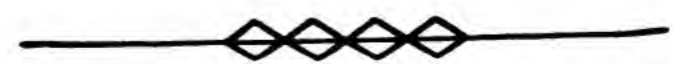
Vacuum-pressure



Thermometer

AERONAUTICAL PIPING SYMBOLS

1. Tube and hose line designations

Service	*Riser or stack*	*Symbol*
Bellows		

Bleed return	BR	- - - - - - - BR - - - - - - -
Drain	D	——————— D ———————
Engine coolant	EC	——————— EC ———————
Foam solution	FO	——————— FOAM ———————
Fuel oil vent	FOV	- - - - - - - FOV - - - - - - -
Fuel supply	F	——————— F ———————

Lubricating oil

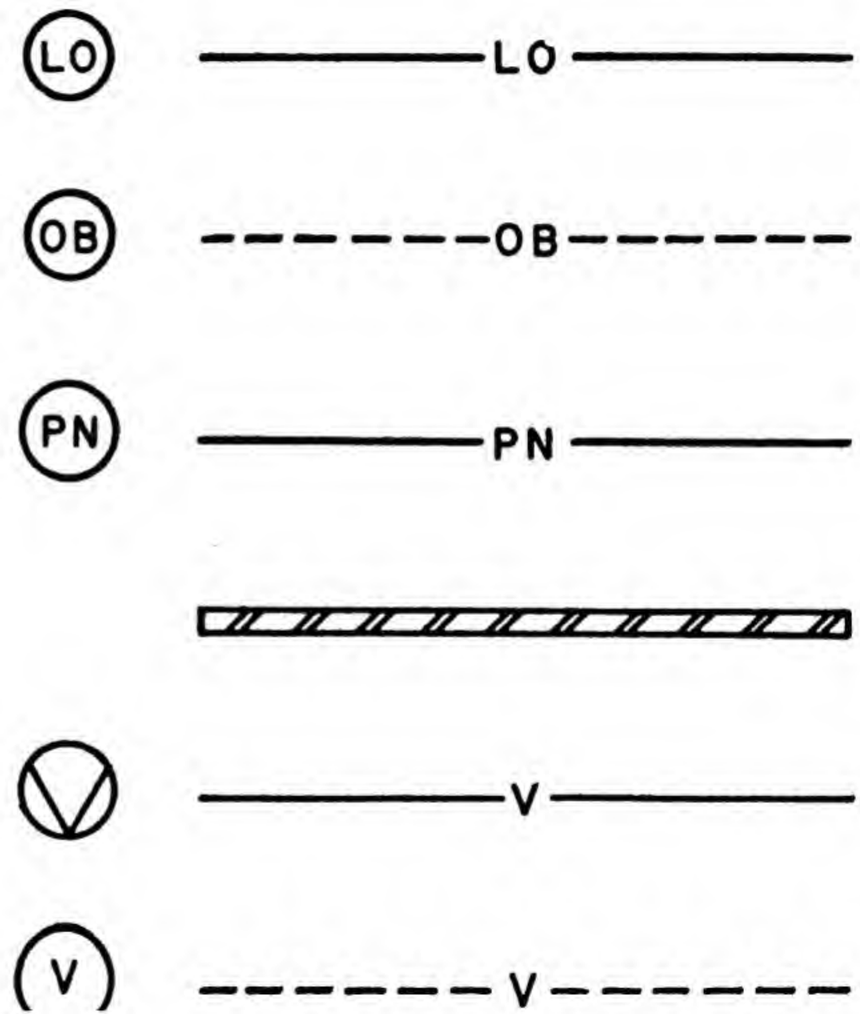
Oil breather

Pneumatic

Self-sealing

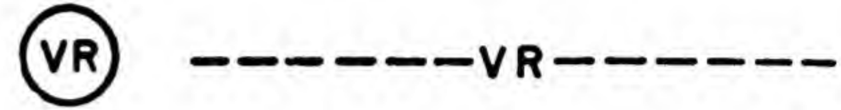
Vacuum

Vent



Vent,pressure

Vent,return



Water injection

Water, cold

Water, hot

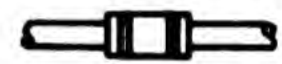
2. Hydraulic tube and hose line designations

Brake

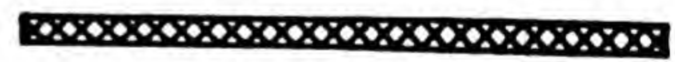
Down (or close)

Emergency pressure

Hose connection, rigid tubing



Hose, flexible



Return

Supply, fluid, pump suction

Suction gravity

Supply, pressure

Up (or open)

Vent

3. **Oxygen tube and hose line symbols**

Distribution (high pressure)

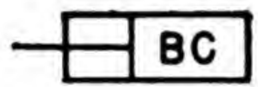
Distribution (low pressure)

Filler

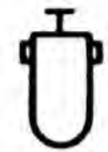
Flexible

4. Hydraulic equipment symbols

Accumulator



Brake control



Filter or strainer

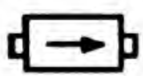
Oxygen unit, portable (continuous flow)

Oxygen unit, portable (demand)

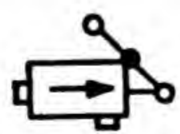
Converter, liquid oxygen

Pump, hand

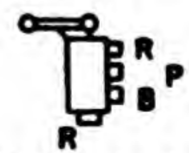
Pump, power driven



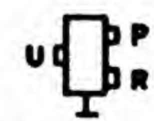
Valve, check, automatic



Valve, check, manual



Valve, brake control



Valve, gun charger control

QUIZ

1. What does a flow diagram usually use in place of symbols?
2. Under what three conditions is it better to use a flow diagram?
3. What type of gears will transmit rotation "around a corner?"
4. What kind of energy is represented by:
   a. Solid lines.
   b. Broken lines.
5. What is the purpose of mechanical schematic diagrams?
6. Do the lines indicating mechanical connections ordinarily represent the actual position of the shafting?
7. In drawing pipe lines on a piping system diagram, why do you use an arrow instead of a plain line as in mechanical schematics?
8. In addition to symbols for identifying components in a piping diagram, how else are components identified?
9. What purpose does a legend serve?
10. Where do you refer for standard mechanical and piping symbols?
11. What two savings are made by using symbols in a diagram?
12. How do you learn to identify the various symbols?
13. In designating the relative importance of piping systems by the use of proper symbols, how would you designate the following:
    a. Principal system.
    b. Second system in importance.
    c. Third system in importance.
    d. Fourth system in importance.
    e. Fifth system in importance.
    f. Invisible lines (adequately labeled as to system).
14. Draw the symbols for the following common pipelines:
    a. Acetylene.
    b. Compressed air.
    c. Fuel supply (except gasoline).
    d. Gasoline.
    e. Oxygen.
    f. Water, fresh.
    g. Water, salt.
    h. Water, hot.
    i. Water, cold.
    j. Carbon dioxide system.
    k. Fire line.
    l. Foam solution.

CHAPTER 11

WELDING SYMBOLS

WELD SYMBOL AND WELDING SYMBOL DEFINED

This chapter is only an introduction to the standard welding symbols which appear on modern blueprints. No attempt is made to define or explain even the few welding terms used in relation to these symbols. It is assumed that you have learned or will learn the meanings of the various welding names and processes, such as braze, resistance, flash, thermit, fillet, and so on, in the course of your welding work or in other texts.

In the Military Standards for welding terminology (and probably in most civilian usage as well) a distinction is made between the terms WELD SYMBOL and WELDING SYMBOL.

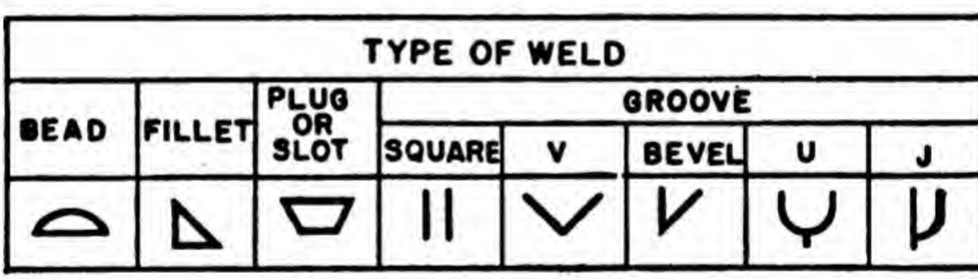


Figure 11-1.—Basic arc and gas weld symbols.

The WELD SYMBOL is a graphic (written) or picture symbol used to indicate the desired type of weld. Figures 11-1, 11-2, and 11-3 illustrate the basic weld symbols. Note that these weld symbols to a great extent resemble in shape the types of welds which they represent. Brazing, forge, thermit, induction, and flow welding are indicated by using a process or specification reference in the tail of the welding symbol.

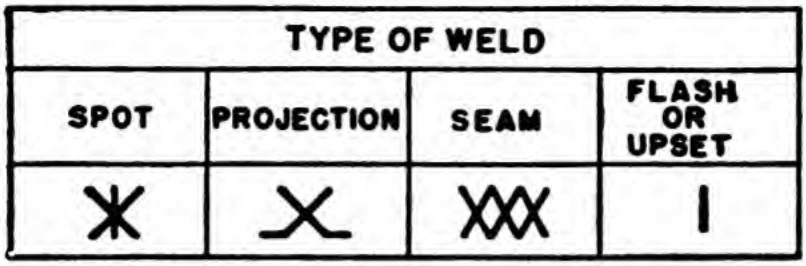


Figure 11-2.—Basic resistance weld symbols.

The WELDING SYMBOL, on the other hand, is the assembled symbol, consisting of some or all of the following elements: Reference line, Arrow, Basic weld symbols, Dimensions and other data, Supplementary symbols, Finish symbols, Tail, Specification, process, or other reference.

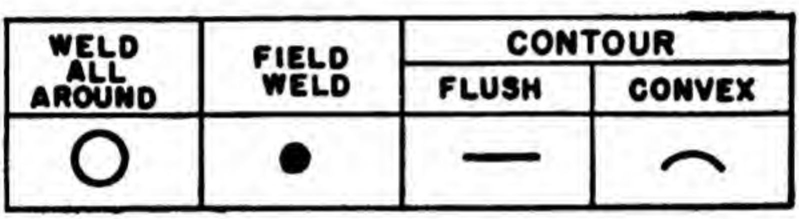


Figure 11-3.—Supplementary symbols.

These elements and their standard locations with respect to each other are illustrated in figure 11-4. Then, after two pages of general information about reading welding symbols, most of the remaining part of the chapter consists of text covering specific types of welds and illustrations showing sample welds with their symbols as they would appear on a blueprint.

HOW TO READ WELDING SYMBOLS

The following information is based on Joint Army-Navy or Military Standards for welding symbols. Reference to the latest JAN or MIL Standards should occasionally be made, as the Standards are subject to change from time to time. A careful study of the following rules and illustrations, plus a little thought as to their interpretation and possible variations, should enable you to meet almost any welding blueprint with confidence.

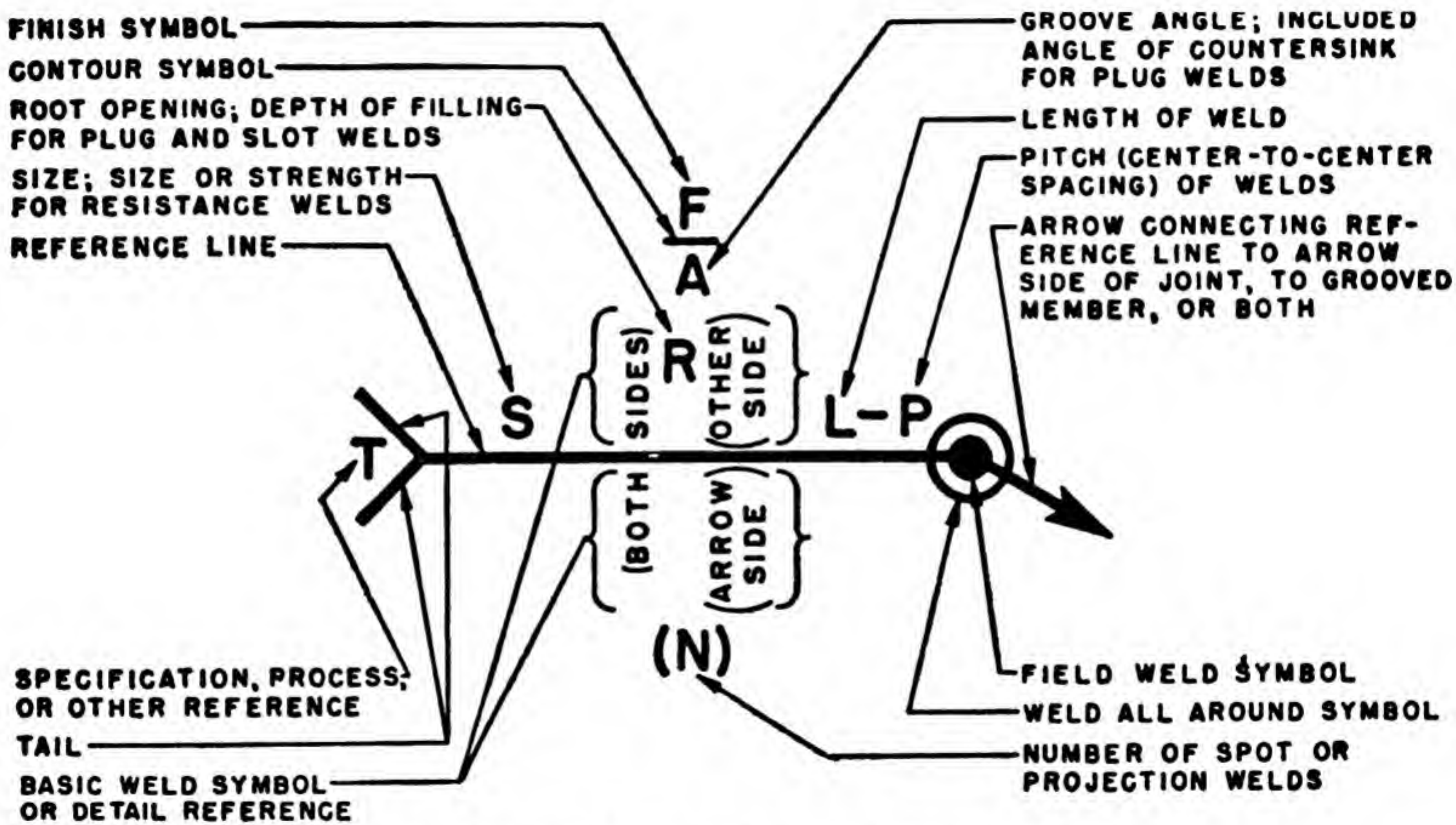
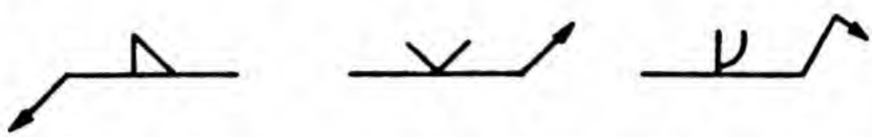


Figure 11-4.—Standard location of elements on a welding symbol.

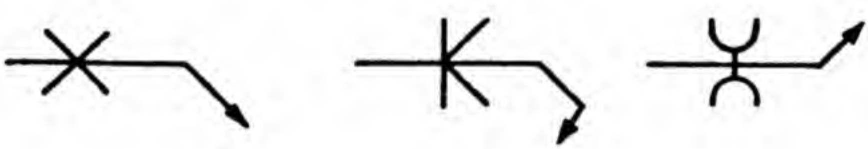
GENERAL

1. Welds on the arrow side of the joint are shown by placing the weld sysmbol on the side of the reference line toward the reader, as follows:

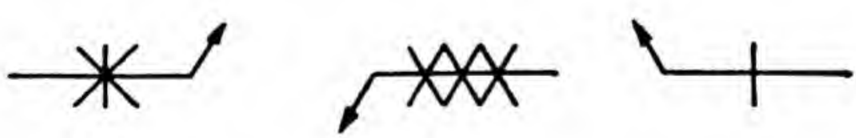
2. Welds on the other side of the joint are shown by placing the weld symbol on the side of the reference line away from the reader, as follows:



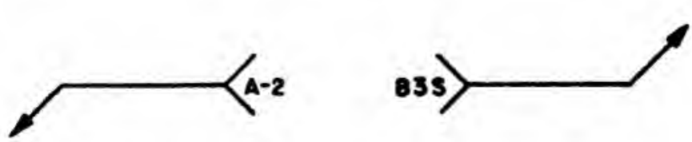
3. Welds on both sides of the joint are shown by placing weld symbols on both sides of the line, as follows:



4. Spot, seam, flash, and upset symbols are centered on the reference line, as follows:

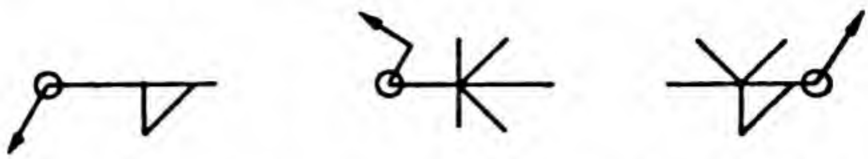


5. A specification, process, or other reference is placed on the tail, as follows (if no reference is required, the tail is omitted):



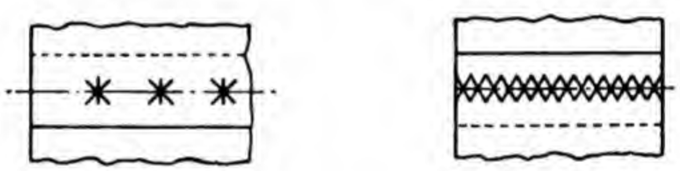
6. General notes or specifications may be placed on the drawing, so that it will not be necessary to repeat references at the various symbols, as: "Unless otherwise indicated, all fillet welds are $\frac{5}{16}$-inch size."

7. Welds extending completely around a joint are indicated by the weld-all-around symbol, as follows:



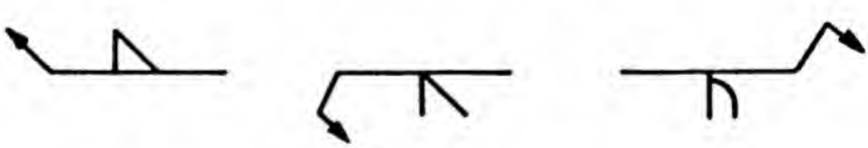
8. Field welds, that is, those made not at the place of original construction but later "in the field," are indicated by the field weld symbol, as follows:

9. Spot and seam weld symbols may be placed directly on drawings at the locations of the desired welds, as follows:

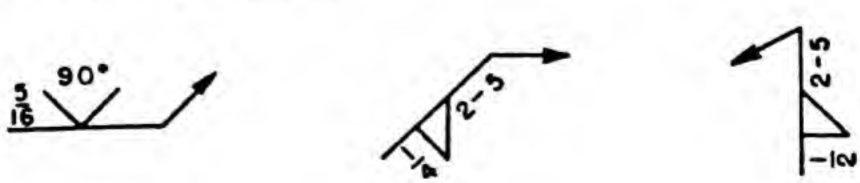


But all other weld symbols are shown only on the welding symbol reference line and never on the lines of the drawing.

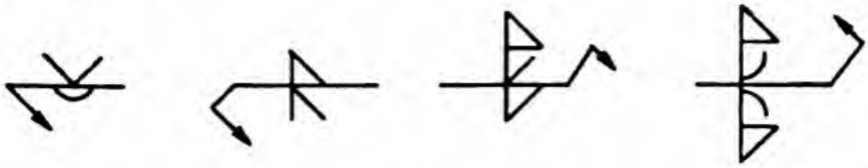
10. Fillet, bevel, and J-groove symbols are shown with the perpendicular leg always to the left, as follows:



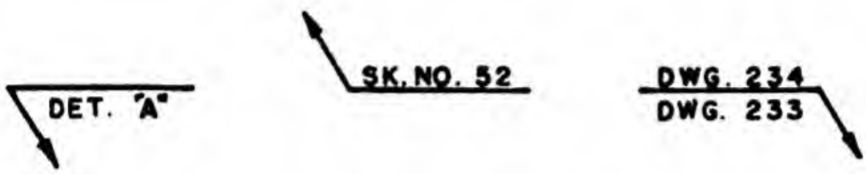
11. Information on welding symbols is read from left to right along the reference line, as follows:



12. When joints have more than one weld, a symbol is shown for each weld, as follows:



13. When the basic weld symbols are inadequate to show all that is needed, the weld is shown by a cross section, detail, or other data with a reference thereto on the welding symbol, as follows:



FILLET WELDS

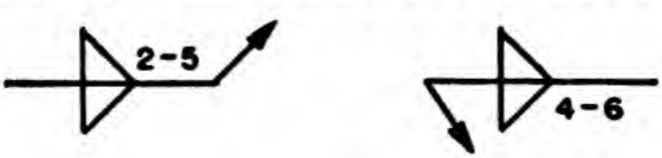
1. The size of a fillet is shown to the left of the weld symbol. If the fillet has unequal legs, the sizes are shown in parentheses to the left of the symbol. (See figure 11–8.)

2. The length of a fillet is shown to the right of the weld symbol. If the weld extends the full length of a piece, no length dimension may be shown. (See figure 11–9, 11–10.)

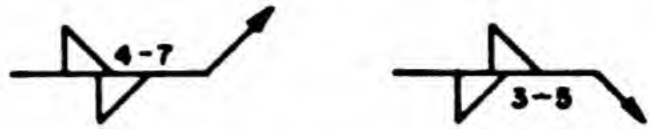
3. Hatching may be used to show the extent of fillet welding:

4. The pitch or center-to-center spacing of intermittent fillet welding is shown to the right of the length dimension:

5. Chain intermittent fillet welding is shown as follows:



6. Staggered intermittent fillet welding is shown as follows:



7. Flat-faced welds are shown by adding the flush-contour symbo to the weld symbol:

8. Welds that are to be made flat-faced or to be finished to a convex contour by mechanical means are shown by adding both the flush-contour symbol or the convex-contour symbol and the user's standard finish symbol to the weld symbol. G indicates grinding; M, machining; and C, chipping.

COMBINED INTERMITTENT AND CONTINUOUS WELDS

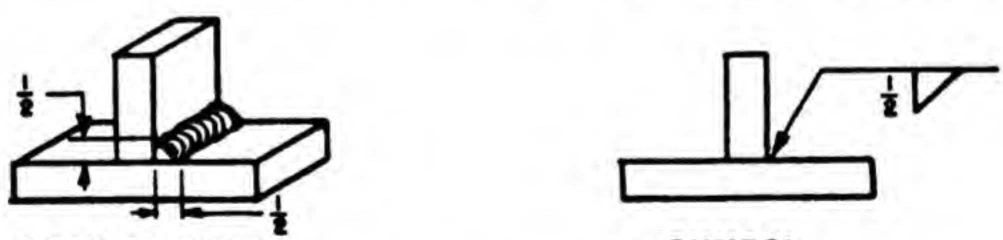


Figure 11-5.—Size of single-fillet weld.

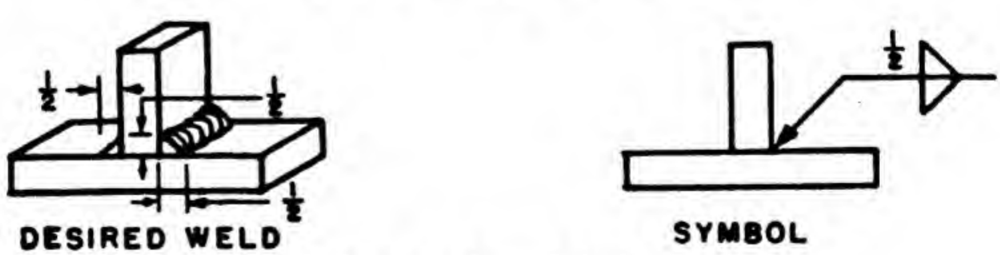


Figure 11-6.—Size of equal double-fillet weld.

Figure 11-7.—Size of unequal double-fillet weld.

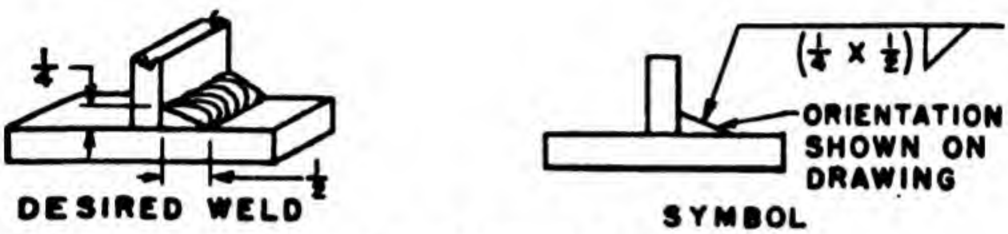


Figure 11-8.—Size of fillet weld having unequal legs.

Figure 11-9.—Continuous fillet weld.

Figure 11-10.—Length of fillet weld.

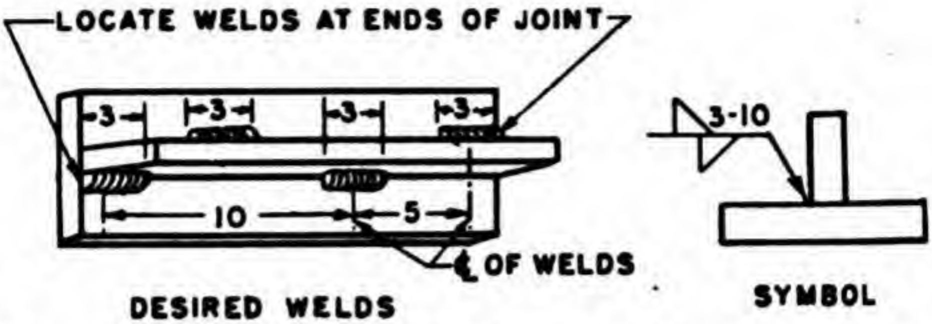


Figure 11–11.—Length and pitch of increments of staggered intermittent welding.

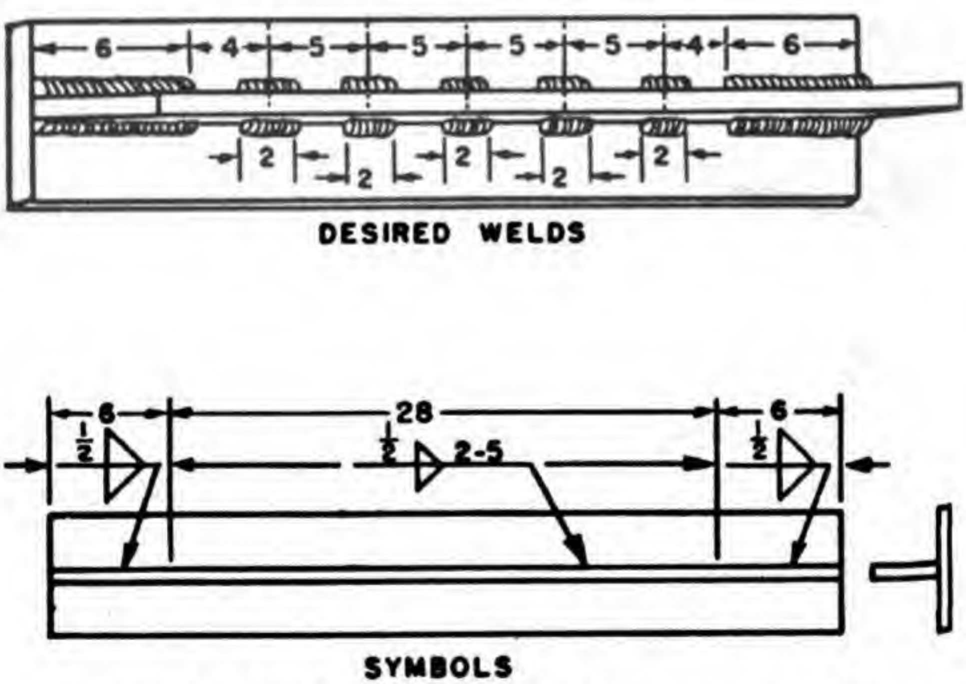
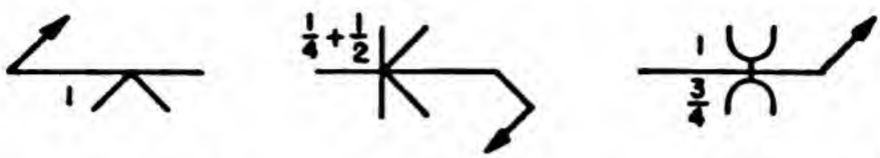


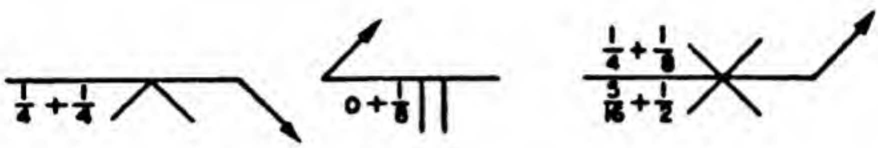
Figure 11–12.—Combined intermittent and continuous welding.

GROOVE WELDS

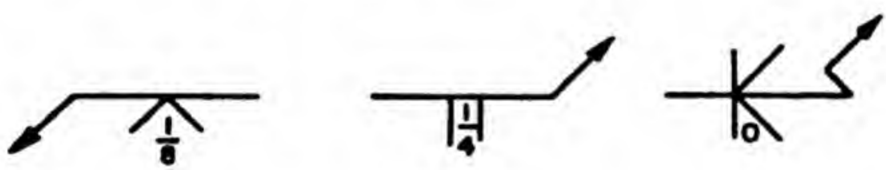
1. The size of groove welds is shown to the left of the weld symbol:



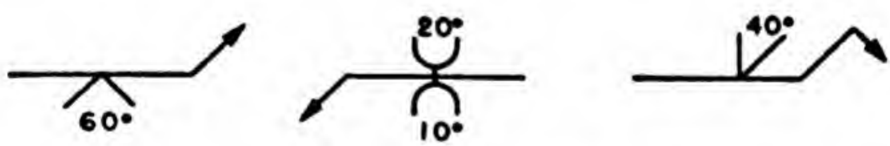
2. The depth of grooving and the root penetration are read in that order, from left to right along the reference line (separated by a plus sign):



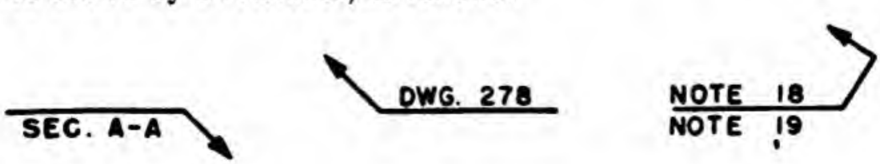
3. Root openings follow the user's standard unless otherwise indicated. When not the user's standard, the dimension of the root opening is shown inside the weld symbol:



4. The groove angles are user's standard unless otherwise indicated. When not the user's standard, the groove weld is shown as follows:



5. Groove radii and root faces of U- and J-groove welds are the user's standard unless otherwise indicated. If not the user's standard, the weld is shown by a reference, as follows:



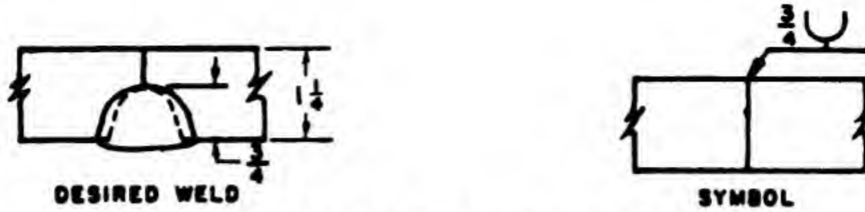


Figure 11-13.—Welds with no specified root penetration.

Figure 11-14.—Welds with specified root penetration.

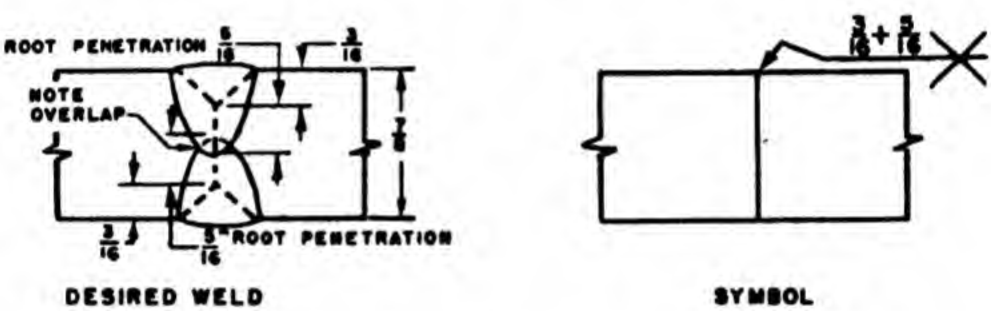


Figure 11-15.—Designation of size of groove welds with specified root penetration.

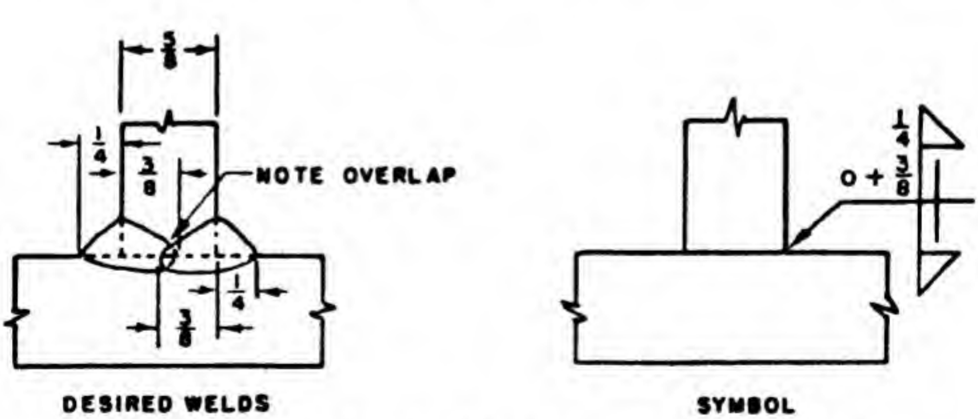


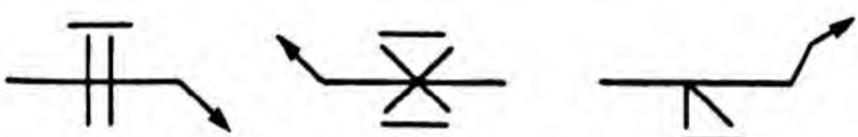
Figure 11-16.—Combined welds with specified root penetration.

Figure 11–17.—Designation of root opening of groove welds.

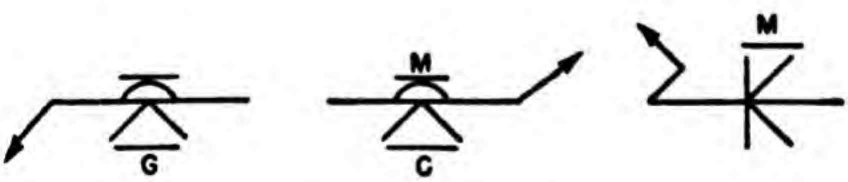
Figure 11–18.—Groove angle or groove welds.

Flush and Contour

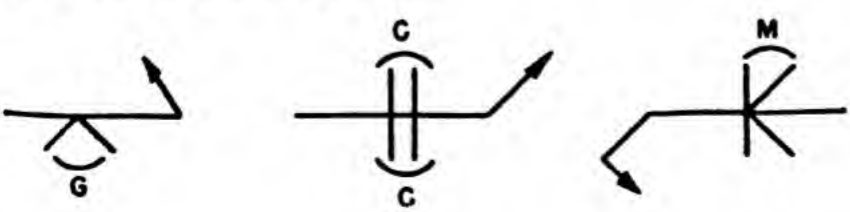
6. Flat-weld groove welds are shown by adding the flush-contour symbol to the weld symbol:



7. If the groove weld is to be made flush not only by flat welding but by mechanical means, the user's standard finish symbol is added to the weld symbol:



8. If a groove weld is to be mechanically finished to a convex contour, both the convex-contour symbol and the user's standard finish symbol is added to the weld symbol:



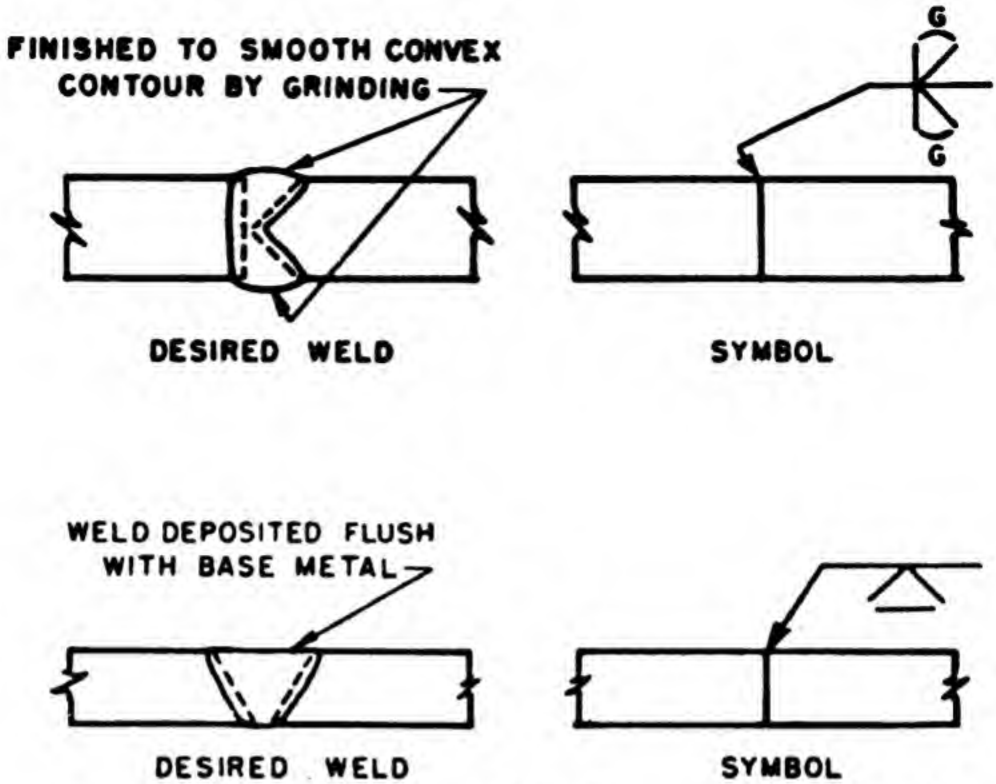
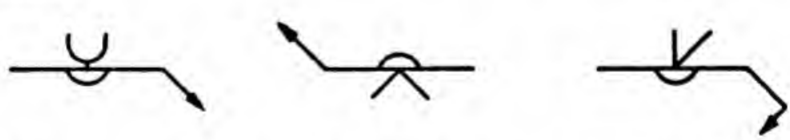


Figure 11-19.—Use of contour symbols with groove welding symbols.

BEAD WELDS (or BACK or BACKING WELDS)

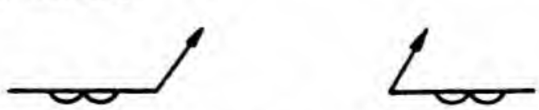
1. The single bead weld symbol is used to indicate bead-type back or backing welds of single-groove welds. (See figure 11-20.) The dual bead weld symbol indicates surfaces built up by welding. (See figure 11-22.)

2. Bead welds used as backing welds are shown by placing a single bead weld symbol on the side of the reference line opposite the groove weld symbol:



3. No dimensions are shown on the welding symbol for bead welds used as back or backing welds. If such dimensions are to be specified, they are so stated on the drawing.

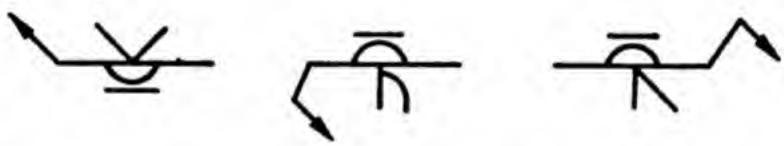
4. The dual bead weld symbol is used to indicate surfaces that are to be built up by welding:



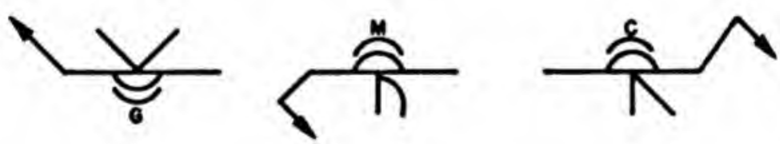
5. Since the dual bead symbol does not indicate a joint, it has no arrow- or other-side significance. The symbol is drawn on the side of the reference line toward the reader, and the arrow points directly to the surface on which the weld is to be deposited. (See figure 11–22.)

6. Dimensions used with the dual bead symbol are shown on the same side as the weld symbol. The size of the surface to be built up is indicated by showing the minimum height of the weld deposit to the left of the weld symbol, as follows (when no specific height is desired, no size dimension need be shown):

7. When backing welds are to be welded approximately flush, the flush-contour symbol is added to the bead weld symbol:



8. When bead welds or backing welds are to be made flush or finished to a convex contour by mechanical means, both the flush-contour symbol or the convex-contour symbol and the user's standard finish symbol are added to the bead weld symbol, thus:



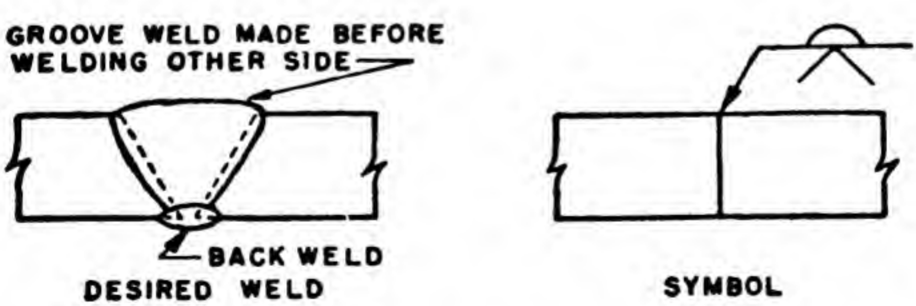


Figure 11–20.—Use of bead weld symbol to indicate single-pass back weld.

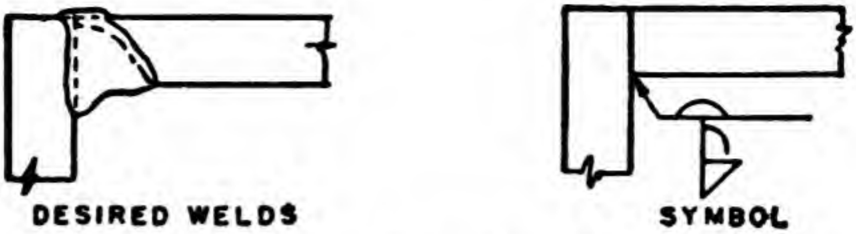


Figure 11–21.—Bead, single-J-groove and fillet weld symbols.

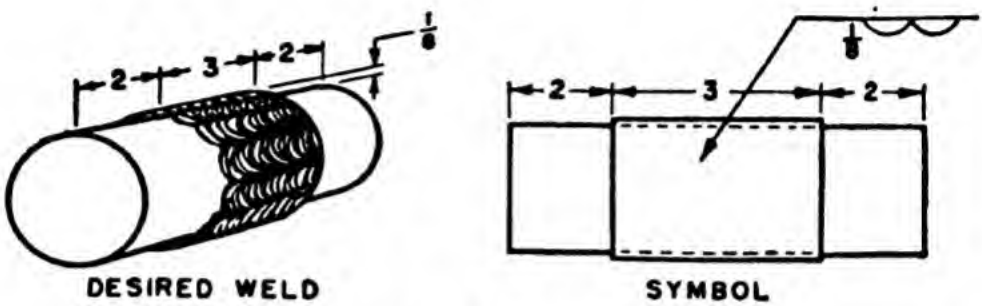


Figure 11–22.—Portion of surface built up by welding.

PLUG WELDS

1. The plug weld symbol is never used to designate fillet welds in holes. Fillet welds in holes and slots are shown by means of the fillet welding symbols.

2. If the hole to be plug welded is on the arrow side, the weld symbol is placed on the side of the reference line toward the reader, as shown in figure 11–23.

3. If the hole is in the other-side member of a joint, the weld symbol is placed on the reference line away from the reader, as shown in figure 11–24.

4. The size of a plug weld is shown to the left of the weld symbol, as follows:

5. The included angle of countersink of the plug weld is the user's standard unless otherwise indicated. If not that of the user, the included angle is shown as follows:

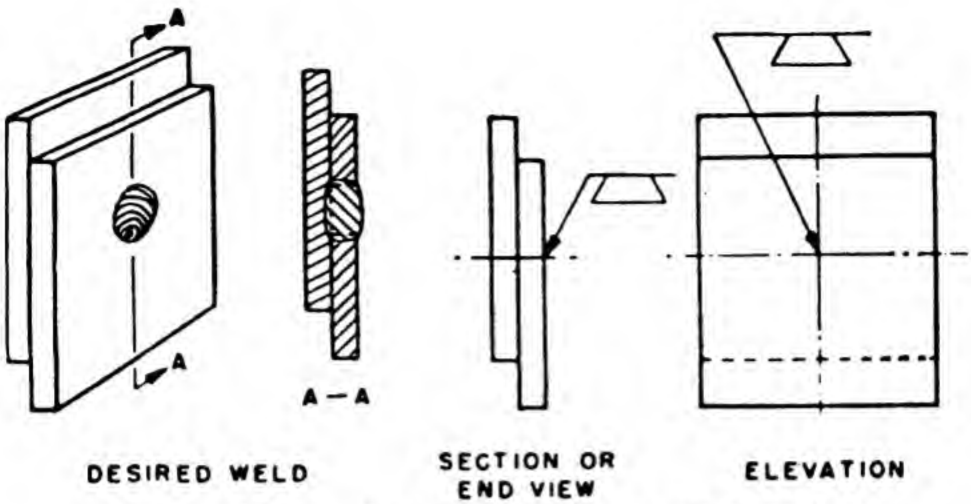


Figure 11-23.—Use of arrow-side plug welding symbol.

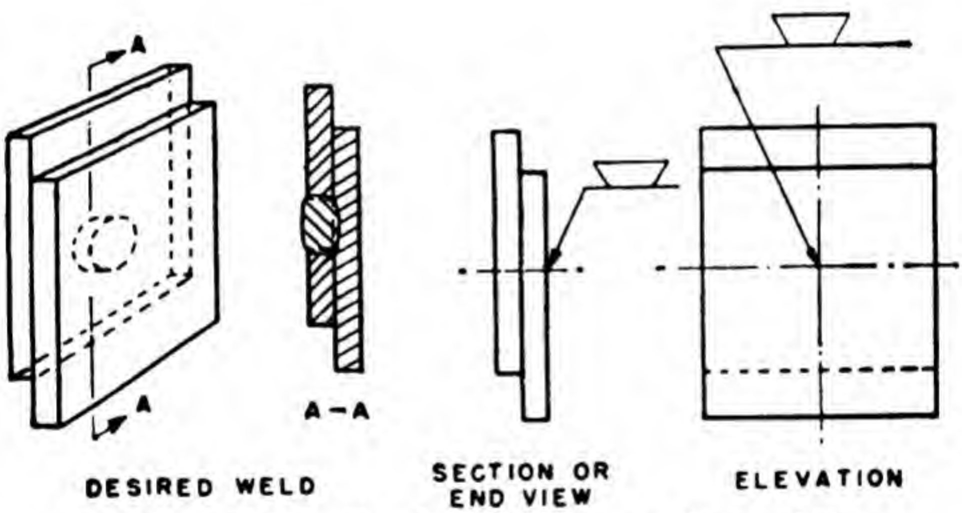


Figure 11-24.—Use of other-side plug welding symbol.

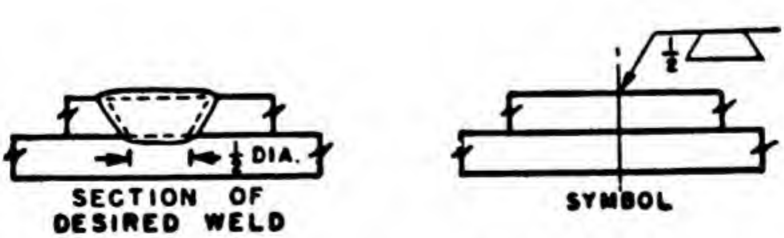
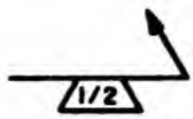
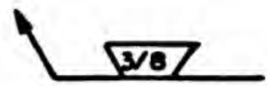


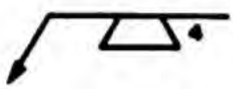
Figure 11-25.—Size of plug weld.

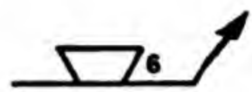
6. The depth of filling of a plug weld is complete unless otherwi indicated. If the filling is to be less than complete, the depth filling, in inches, is shown inside the weld symbol, as follows:



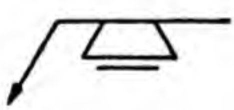


7. The pitch, that is, the center-to-center spacing, of plug welds shown to the right of the weld symbol:

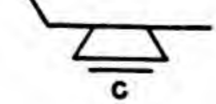


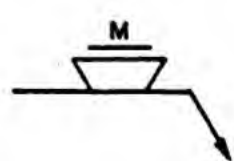


8. The flush-contour symbol is added to the weld symbol when plug weld is to be welded approximately flush without using an method of machining, as follows:



9. If a plug weld is to be made flush by mechanical means, both th flush-contour symbol and the user's standard finish symbol are addec to the weld symbol, as follows:





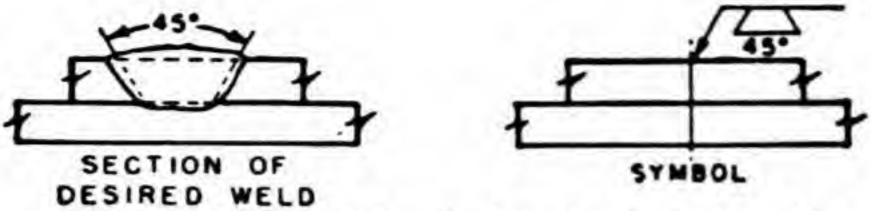


Figure 11-26.—Included angle of countersink of plug welds.

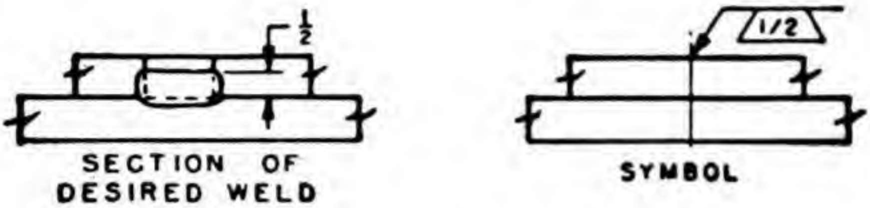


Figure 11-27.—Depth of filling of plug welds.

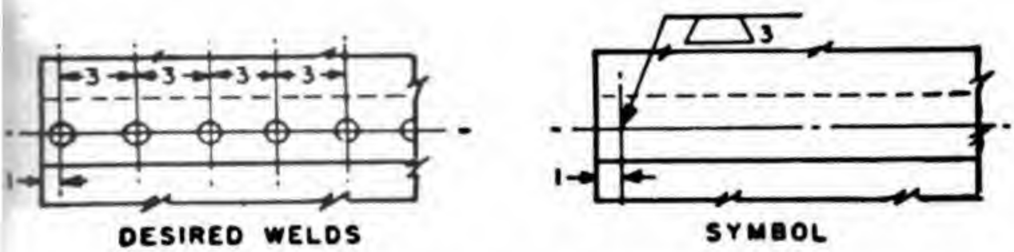


Figure 11-28.—Pitch of plug welds.

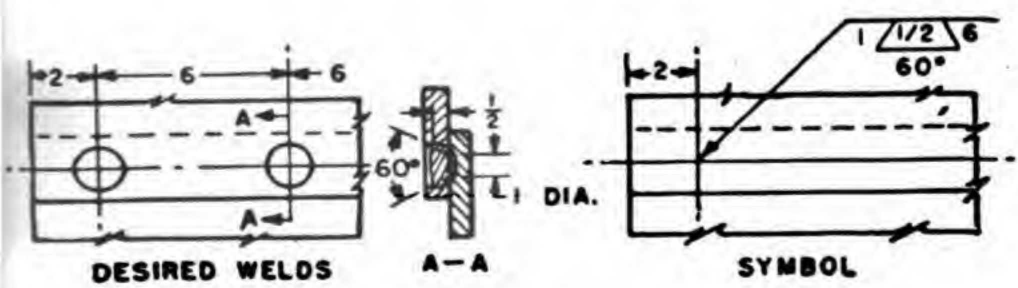
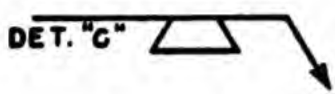
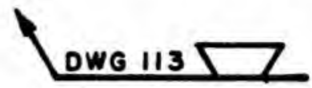


Figure 11-29.—Plug welding symbol showing use of combined dimensions.

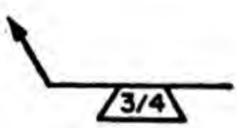
SLOT WELDS

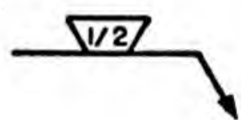
1. The weld symbol for a slot weld is the same as that for a plug weld. (Its meaning is clearly shown by the slot hole on the drawing.) But the length, width, spacing, included angle of countersink, orientation, and location of slot welds cannot be shown on the welding symbol. These data are shown on the drawing or by a detail, with a reference on the welding symbol, as follows:





2. The depth of the filling, however, may be indicated. If the slot is completely filled, no notation is made. When the depth of filling is less than complete, the depth of filling in inches is shown inside the weld symbol, as follows:





3. Slots in the arrow-side member of a joint for slot welding are indicated by placing the weld symbol on the side of the reference line toward the reader. (See figure 11–30.)

4. Slots in the other-side member of a joint for slot welding are indicated by placing the weld symbol on the side of the reference line away from the reader. (See figure 11–31.)

5. The slot weld symbol is never used to designate fillet welds in slots.

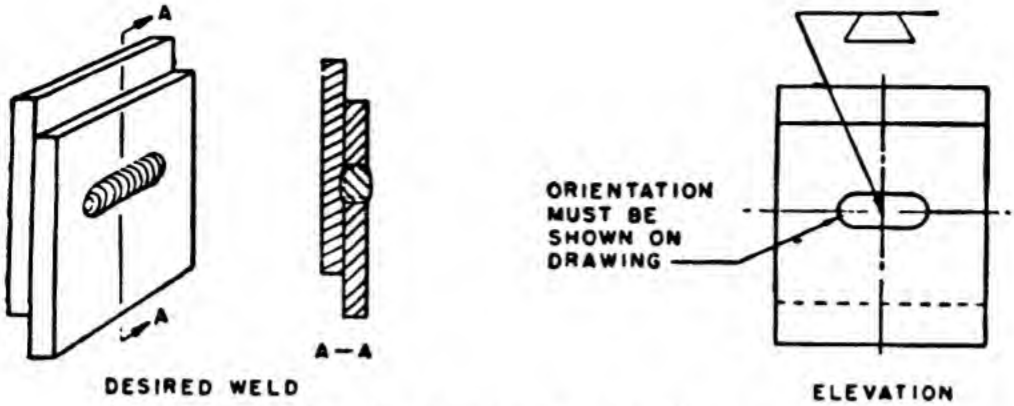


Figure 11-30.—Use of arrow-side slot welding symbol.

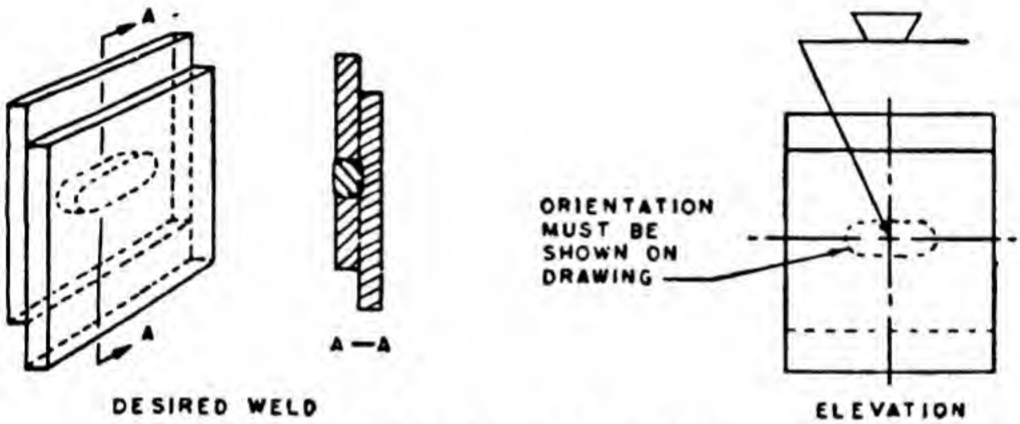


Figure 11-31.—Use of other-side slot welding symbol.

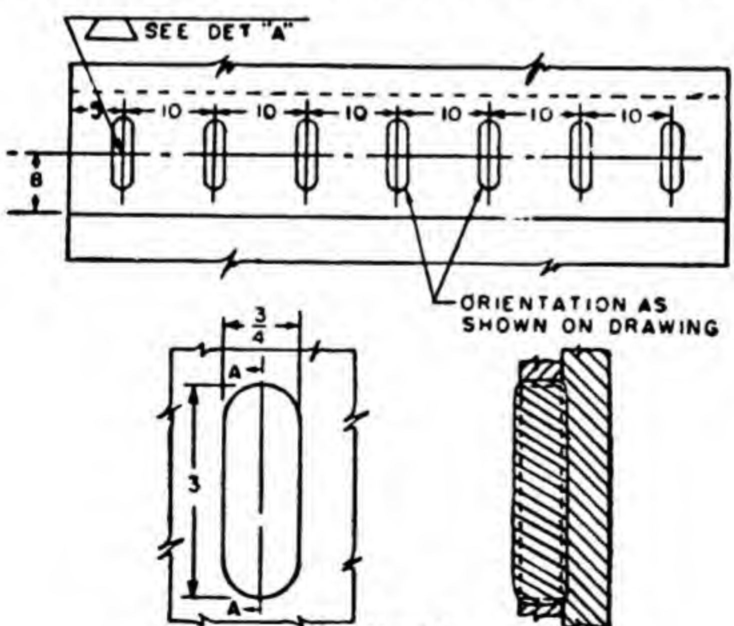
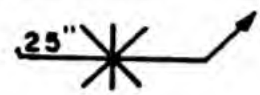


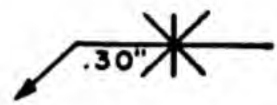
Figure 11-32.—Completely filled slot welds.

SPOT WELDS

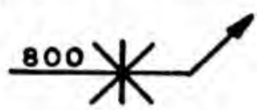
1. Spot weld symbols have no arrow- or other-side significance in themselves. Other symbols used along with spot symbols may have such significance. Spot weld symbols are centered on the reference line. The dimensions may be shown on either side of the reference line.

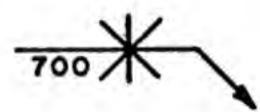
2. Spot welds are dimensioned either by size or strength. The size is designated as the diameter of the weld expressed decimally in hundredths of an inch and is shown with inch marks to the left of the weld symbol, as follows:



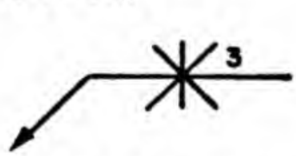


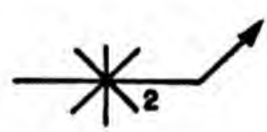
3. The strength of spot welds is designated as the minimum acceptable shear strength in pounds per spot and is shown to the left of the weld symbol, as follows:



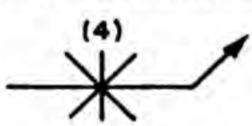


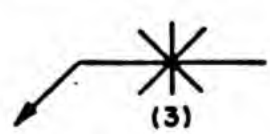
4. The pitch (center-to-center spacing) of spot welds is shown to the right of the weld symbol, shown below. (When spot weld symbols are shown directly on the drawing, the spacing is shown by dimensions, as in figure 11–37.)



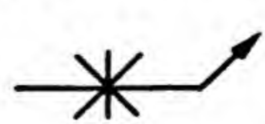


5. When a definite number of spot welds is desired, the number is shown in parentheses, above or below the symbol, as follows:





6. When the exposed surface of one member of a spot-welded joint is to be flush, that surface is indicated by adding the flush-contour symbol to the weld symbol, observing the proper location significance as follows:



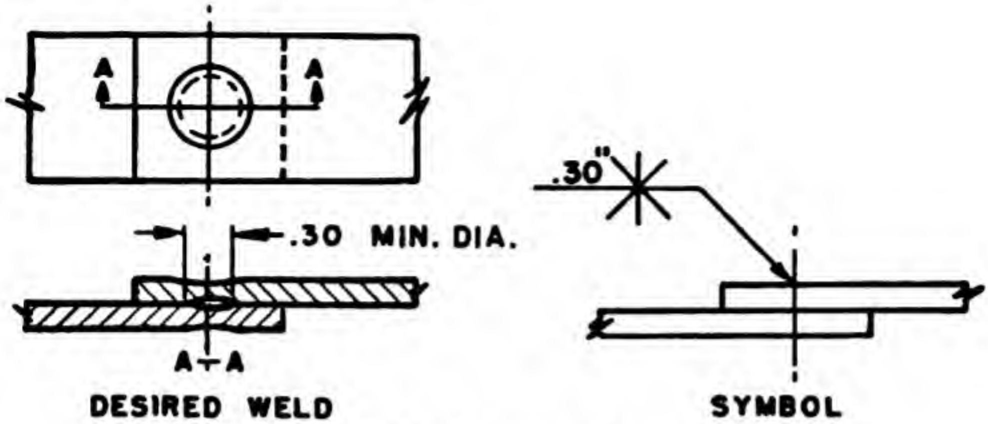


Figure 11-33.—Diameter of spot welds.

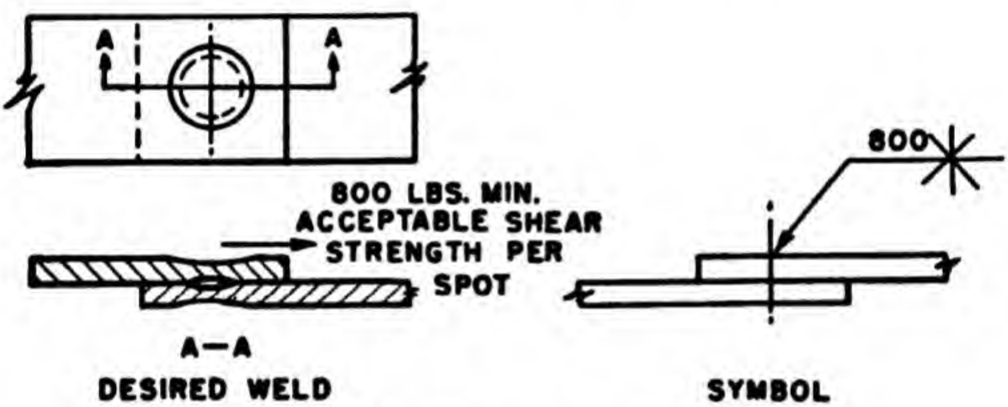


Figure 11-34.—Shear strength of spot welds.

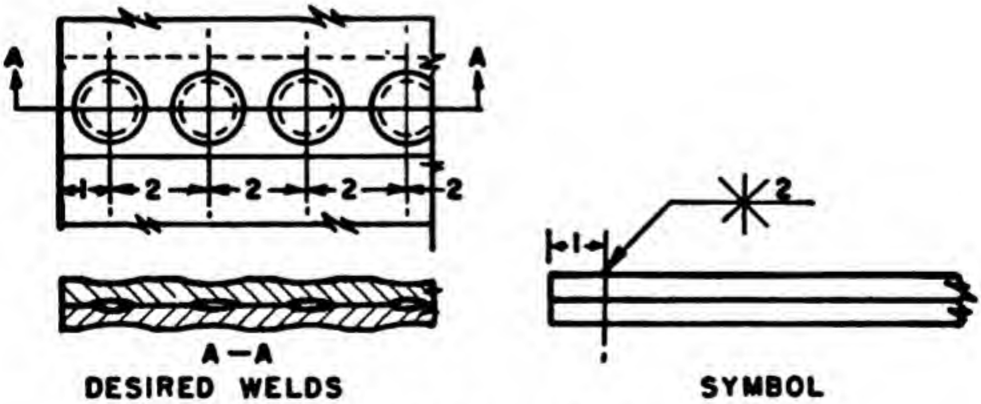


Figure 11-35.—Pitch of spot welds shown on symbol.

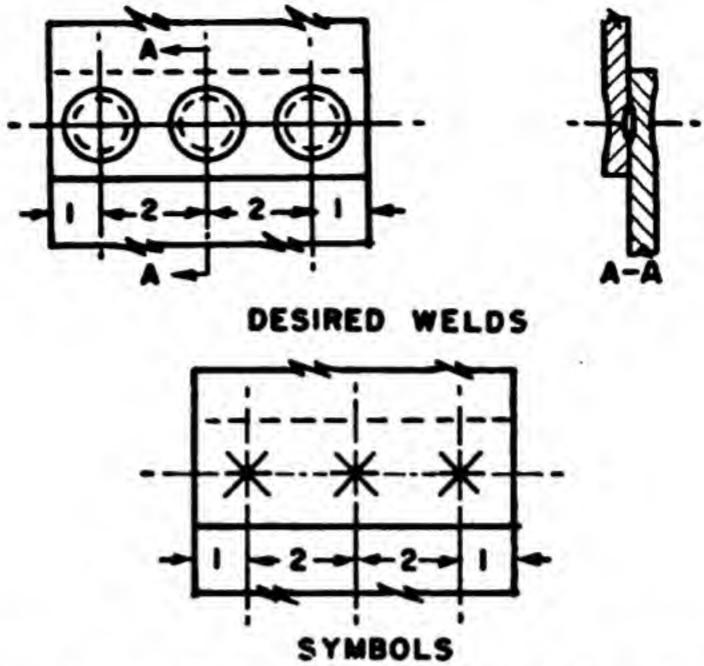


Figure 11-36.—Pitch of spot welds with symbols on drawing.

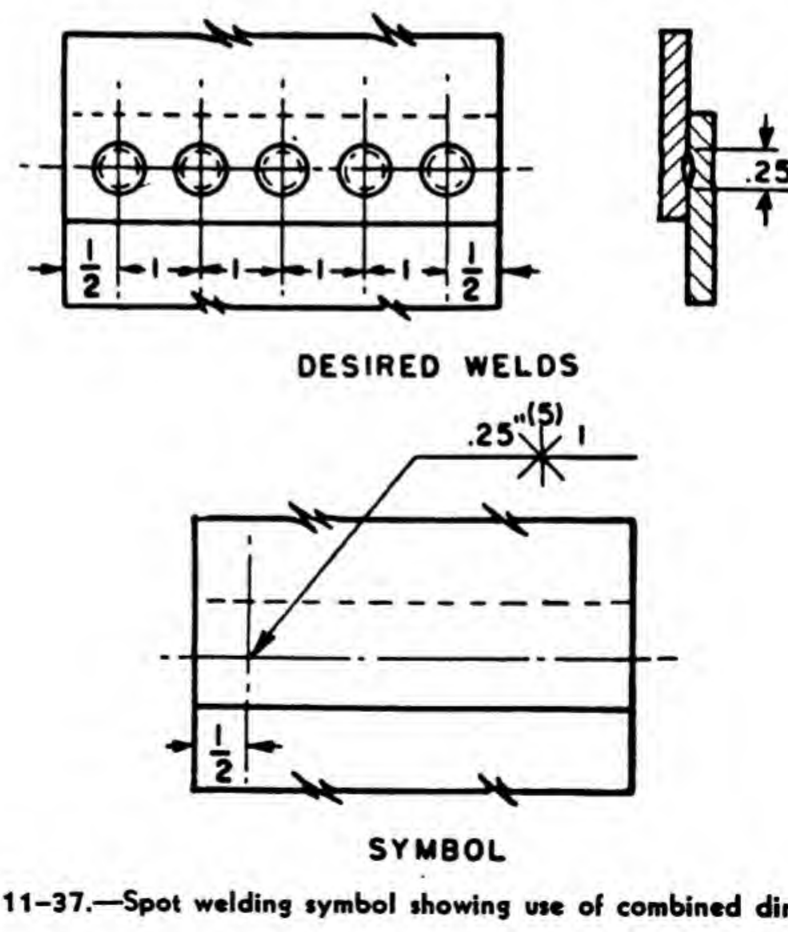
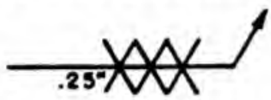


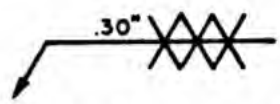
Figure 11-37.—Spot welding symbol showing use of combined dimensioı

SEAM WELDS

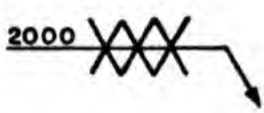
1. Seam weld symbols have no arrow- or other-side significance in themselves. Other symbols used with them may have such significance. Seam weld symbols are centered on the reference line. Their dimensions may be shown on either side of the reference line.

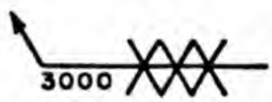
2. Seam welds are dimensioned either by size or by strength. The size of the weld is designated as the width of the weld expressed decimally in hundredths of an inch and is shown with inch marks to the left of the weld symbol:



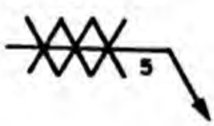


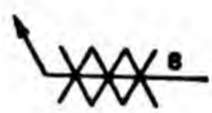
3. The strength of seam welds is designated as the minimum acceptable shear strength in pounds per linear inch and is shown to the left of the weld symbol:



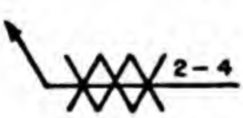


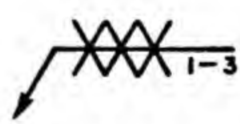
4. The length of a seam weld, when indicated, is shown to the right of the weld symbol:



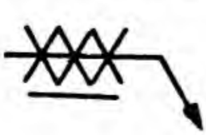


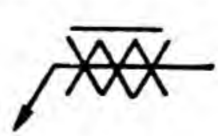
5. The pitch (center-to-center spacing) of intermittent seam welding is shown as the distance between centers of the welds and is placed to the right of the length dimension.





6. When the exposed surface of one member of a seam-welded joint is to be flush, that surface is indicated by adding the flush-contour symbol to the weld symbol, observing the proper location, as follows:





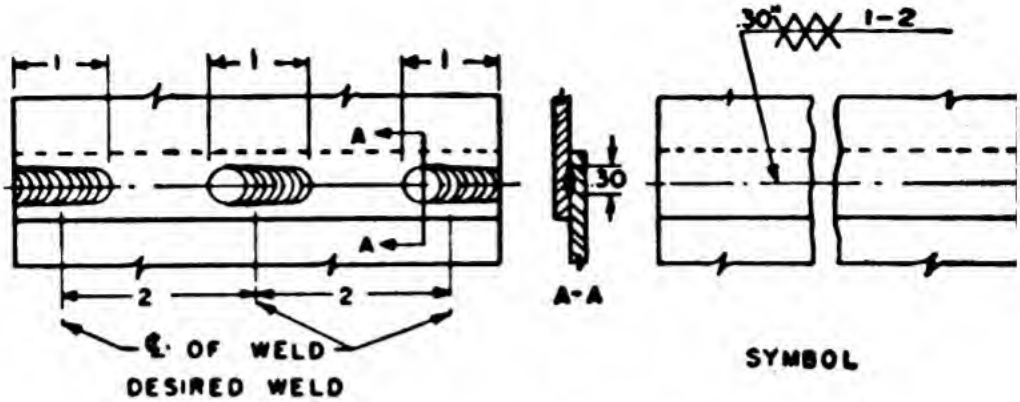


Figure 11-38.—Length and pitch of intermittent seam welds.

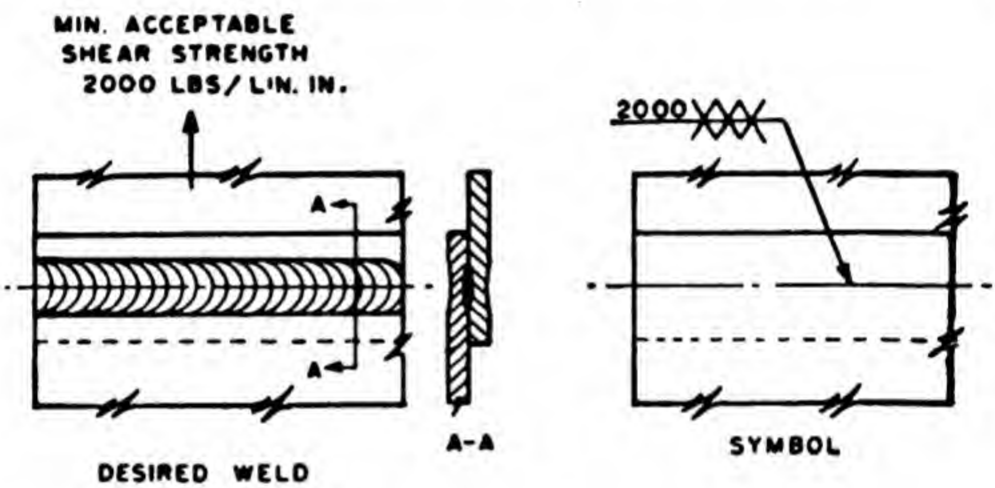


Figure 11-39.—Strength of seam welds.

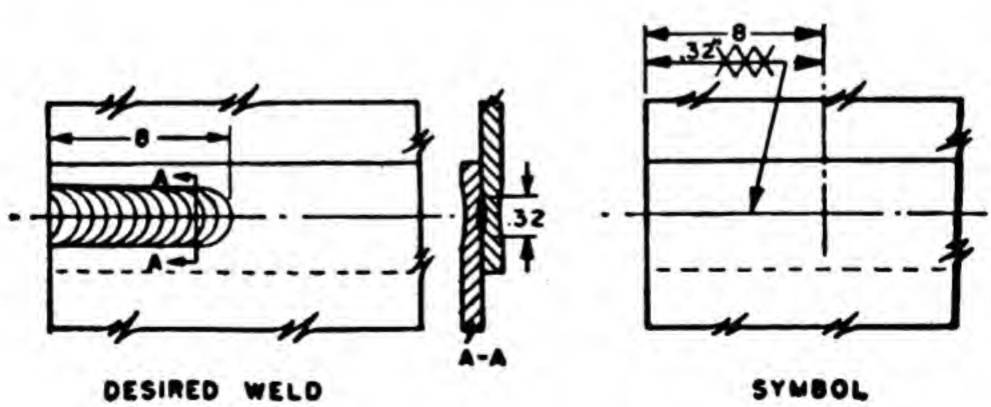
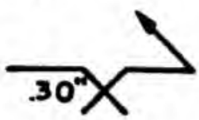


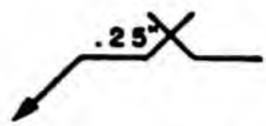
Figure 11-40.—Extent of seam welds.

PROJECTION WELDS

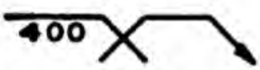
1. When the embossment is on the arrow-side of the joint, the weld symbol is placed on the side of the line toward the reader. When it is on the other side, the symbol appears on the side of the reference line away from the reader. The proportions of the projections are shown by a detail or other suitable means.

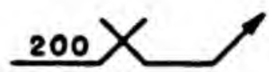
2. Projection welds are dimensioned either by size or by strength. The size is designated as the diameter of the weld expressed decimally in hundredths of an inch and is shown with inch marks to the left of the symbol:



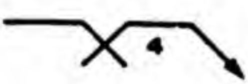


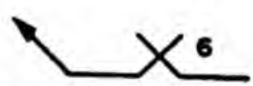
3. The strength of projection welds is designated as the minimum acceptable shear strength in pounds per weld and is shown to the left of the symbol:



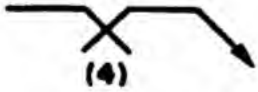


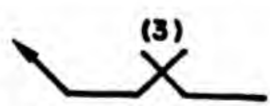
4. The pitch (center-to-center spacing) of projection welds is shown to the right of the weld symbol:



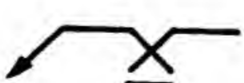


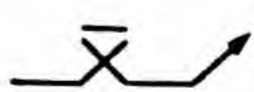
5. When a definite number of welds is desired, the number is shown in parentheses:





6. When the exposed surface of one member of a projection-welded joint is to be flush, that surface is indicated by adding the flush-contour symbol to the weld symbol, in accordance with the usual location significance.





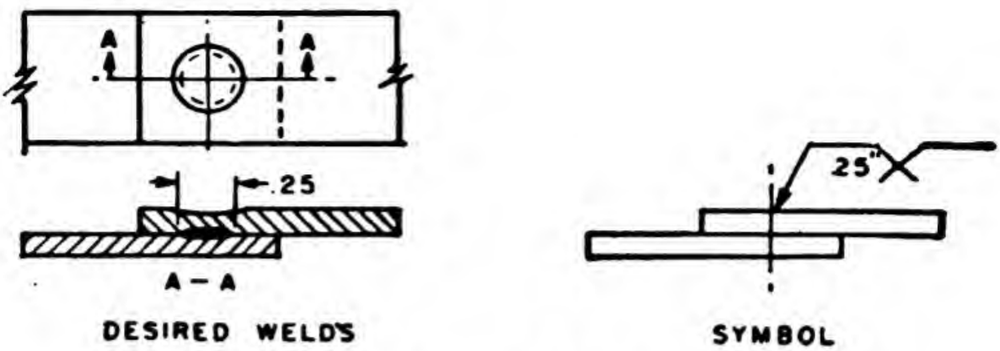


Figure 11-41.—Diameter of projection welds.

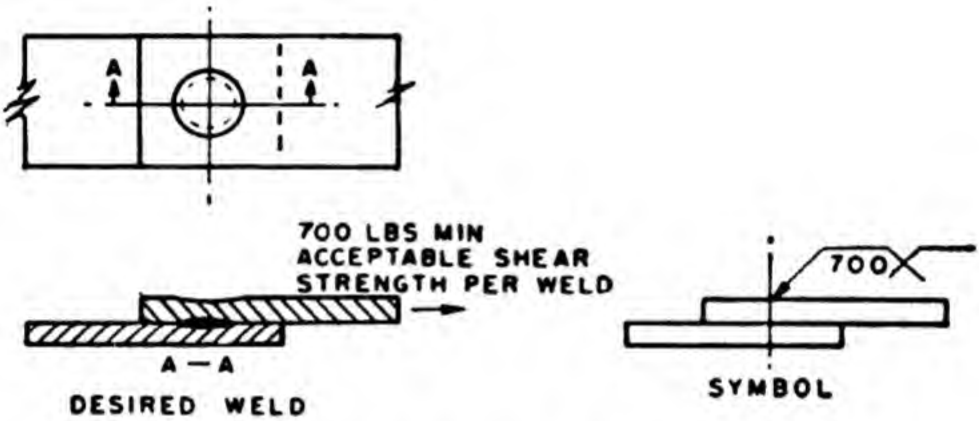


Figure 11-42.—Shear strength of projection welds.

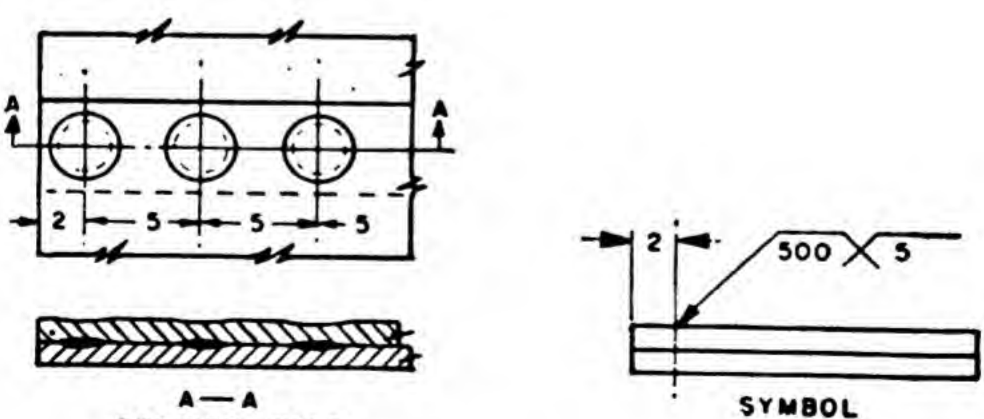


Figure 11-43.—Pitch of projection welds.

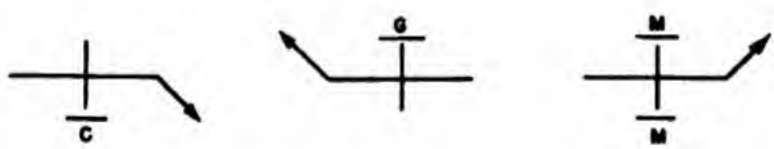
FLASH AND UPSET WELDS

1. Flash and upset weld symbols have no arrow- or other-side significance in themselves. Other symbols used along with them may have such significance.

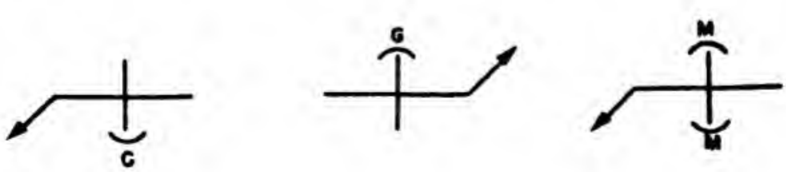
2. Flash or upset weld symbols are centered on the reference line.

3. No dimensions for flash and upset welds are shown on the welding symbol.

4. Flash and upset welds that are to be made flush by mechanical means are shown by adding both the flush-contour symbol and the user's standard finish symbol to the weld symbol, keeping the usual location significance, as follows:



5. Flash and upset welds that are to be mechanically finished to a convex contour add both the convex-contour symbol and the user's standard finish symbol to the weld symbol. The usual location significance is observed as follows:



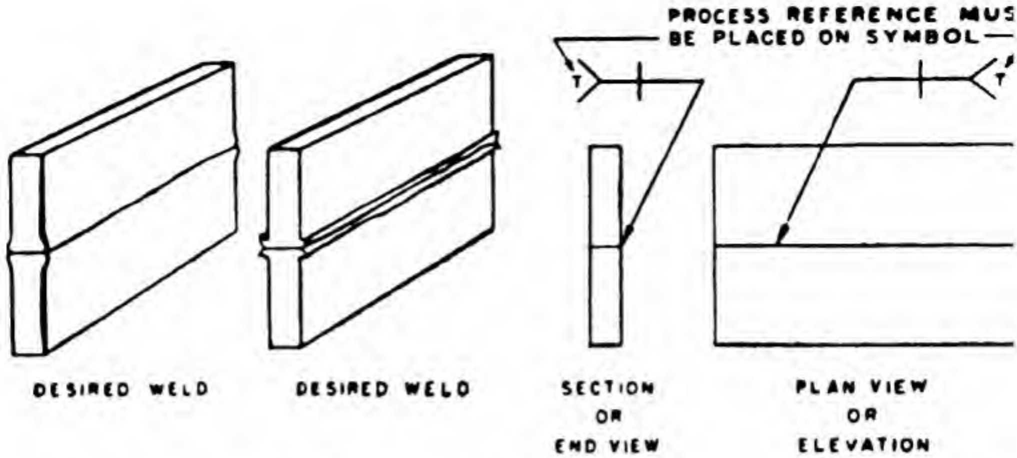


Figure 11-44.—Flash or upset welding symbol—no arrow- or other-side significance.

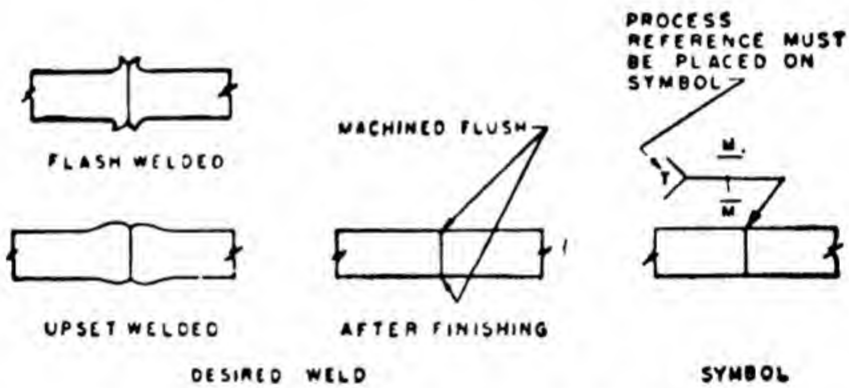


Figure 11-45.—Flash and upset welds finished flush.

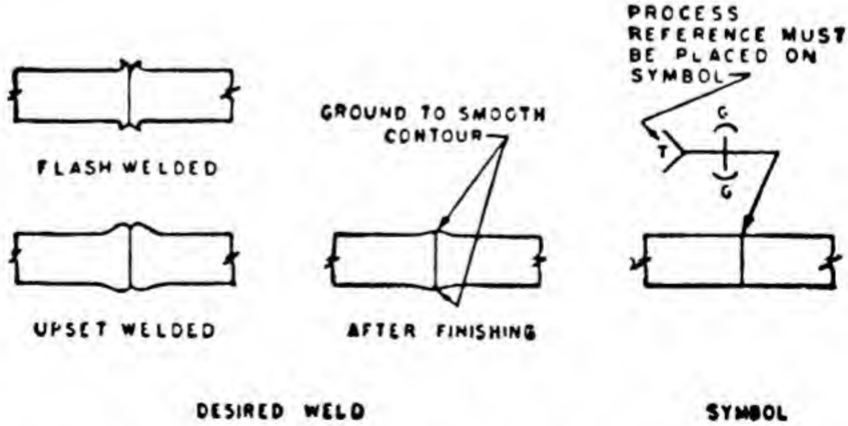


Figure 11-46.—Flash and upset welds finished to smooth contour.

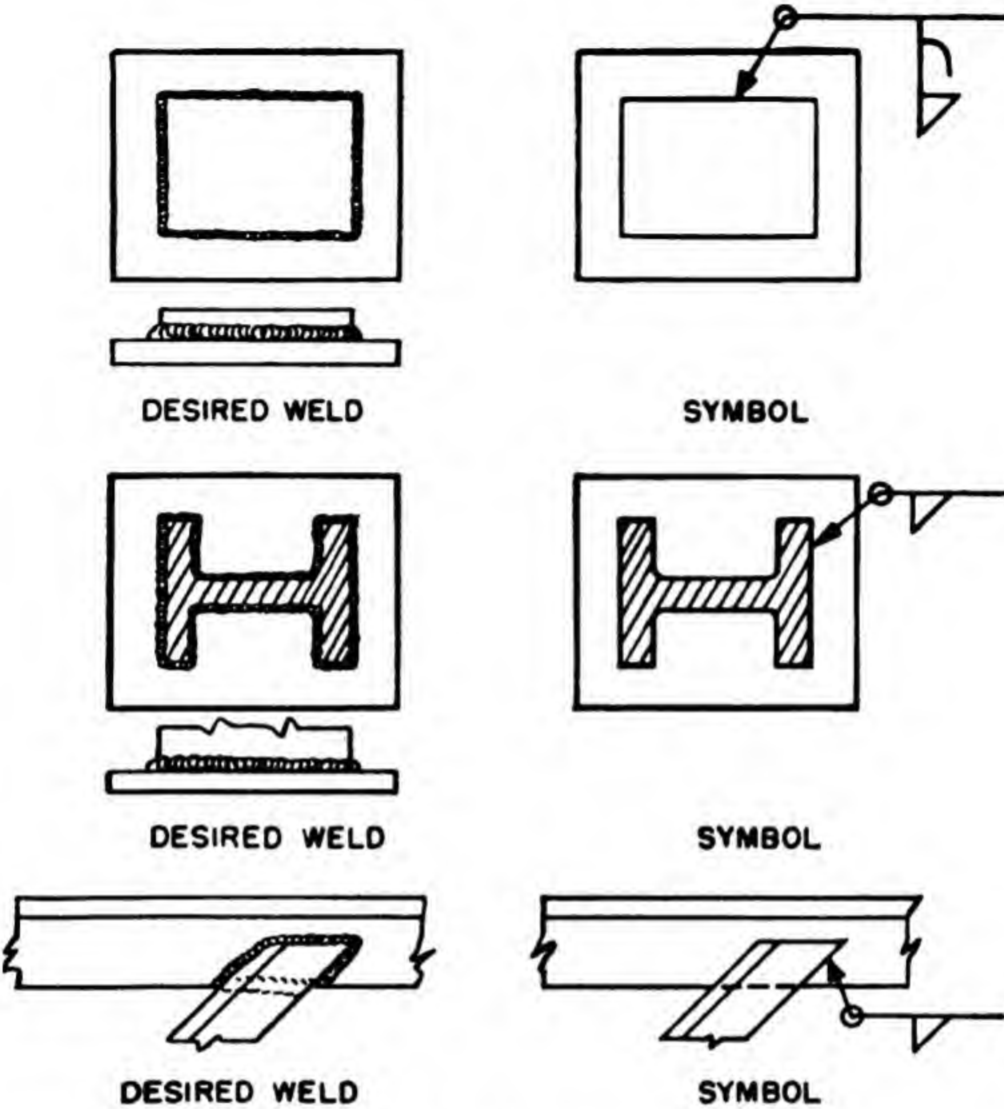


Figure 11-47.—Use of the weld-all-around symbol.

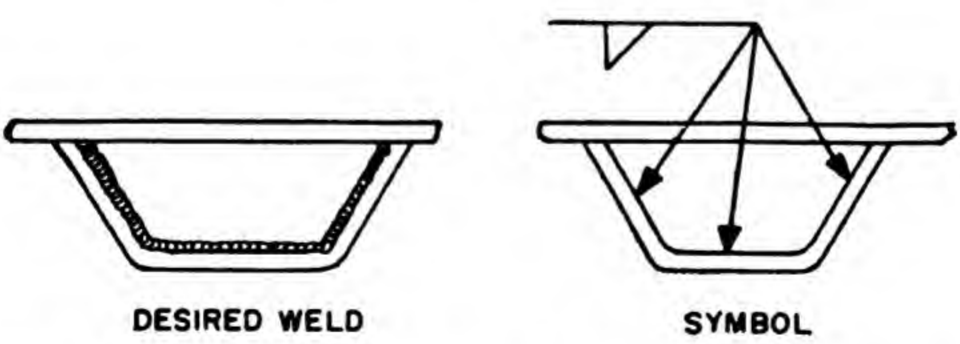


Figure 11-48.—Designating a weld with abrupt changes of direction.

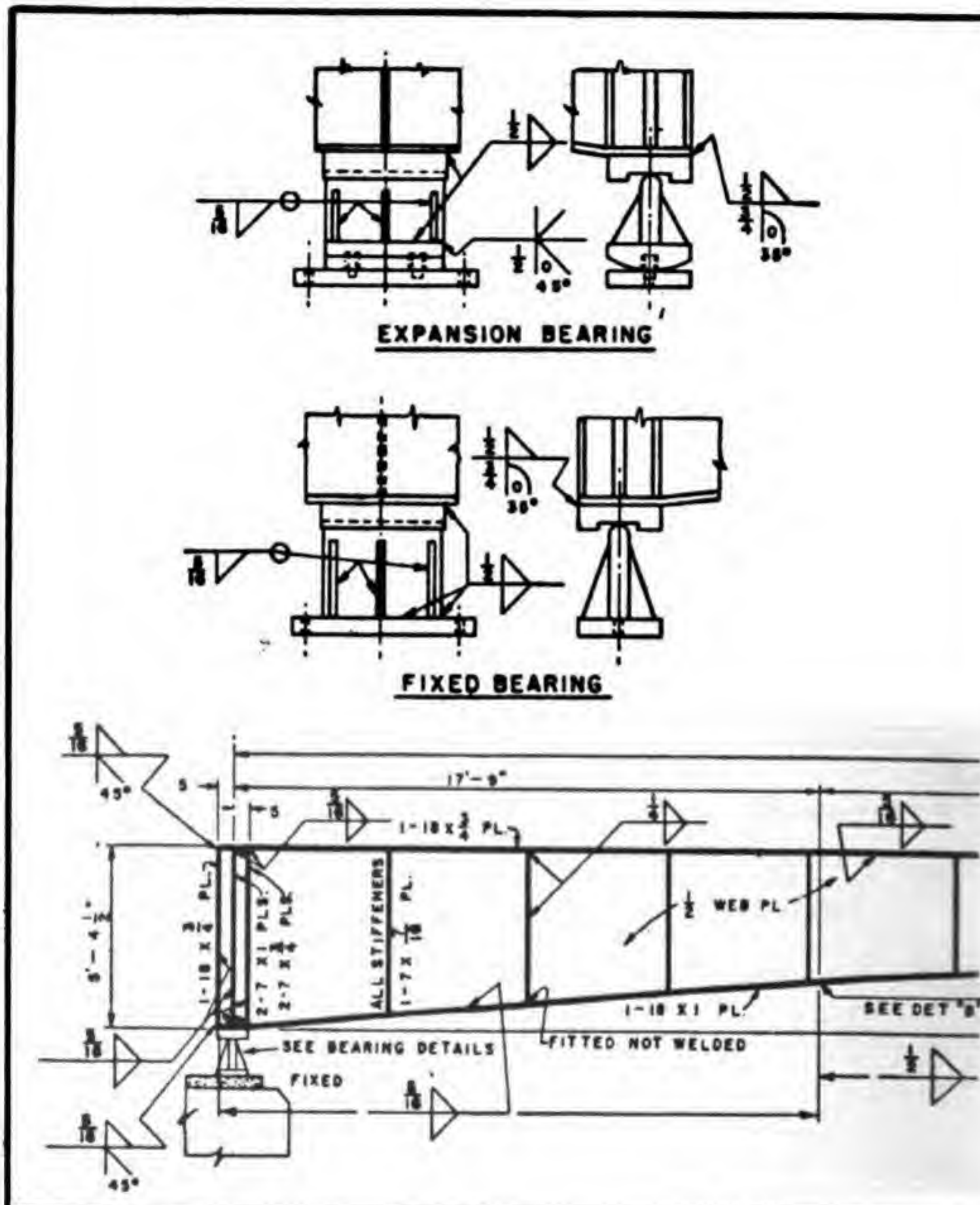
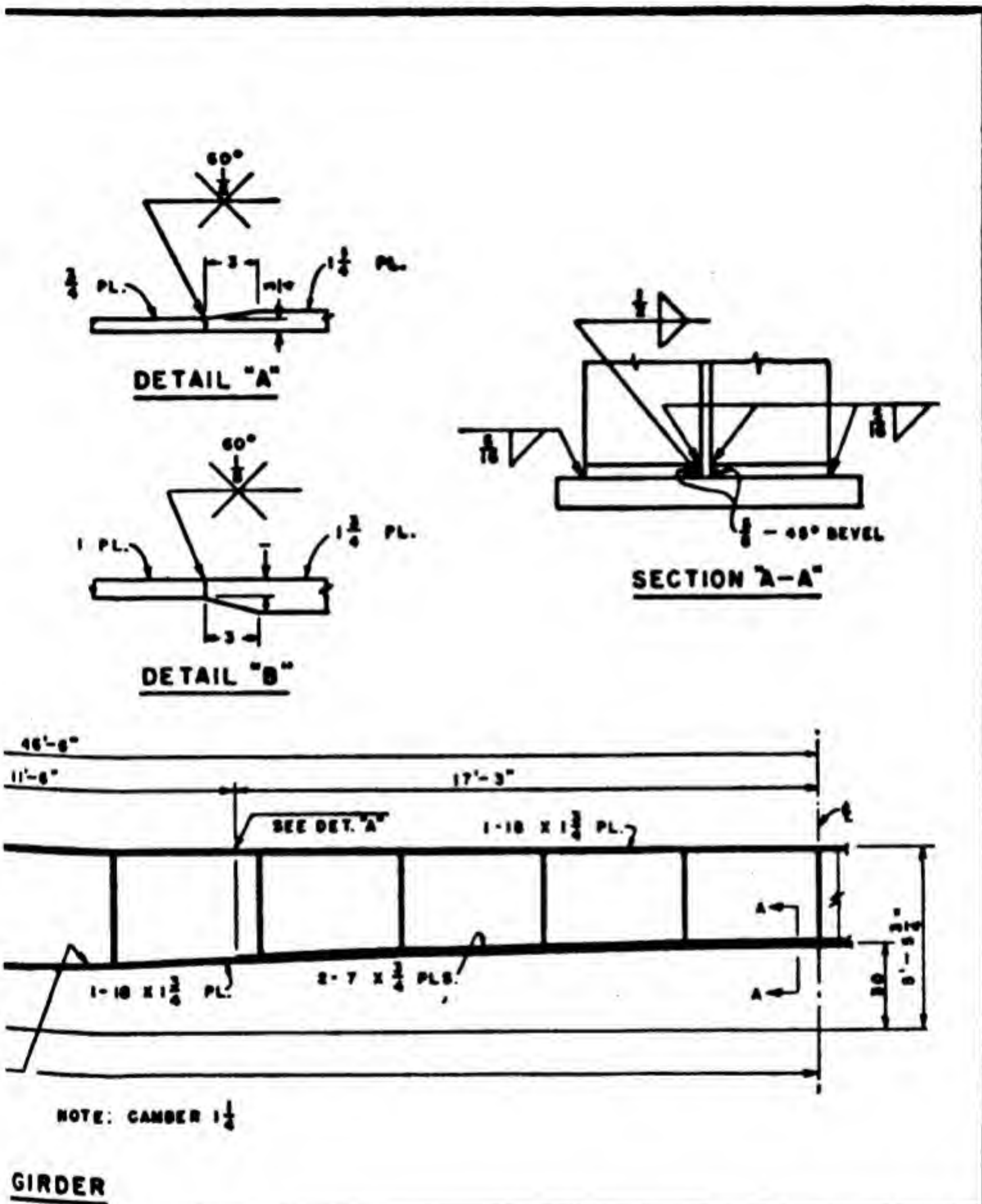


Figure 11-49.—Use of welding



symbols on structural drawing.

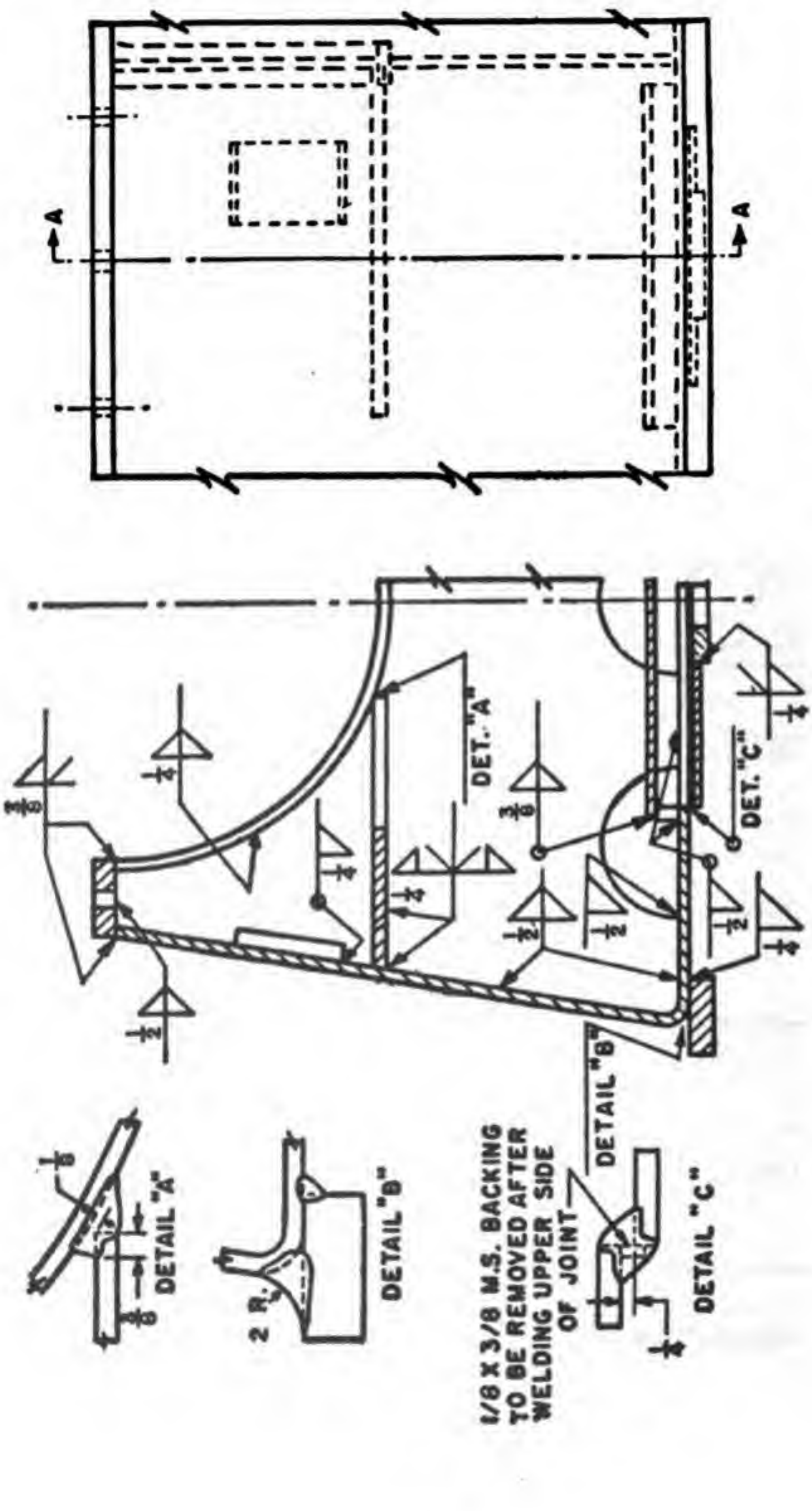


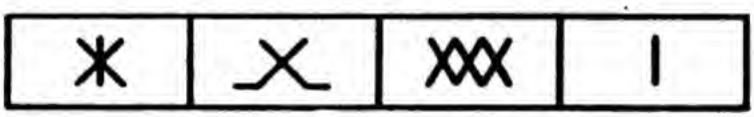
Figure 11-50.—Use of arc and gas welding symbols on machinery.

QUIZ

1. Which contains more information, the *weld symbol* or the welding symbol?
2. Since there are no weld symbols for brazing, forge, thermit, induction, and flow welding, what is used?
3. If the weld is to be on the side of the joint toward the arrow, where should the weld symbol be placed?
4. What is there about weld symbols that helps you to read them?
5. List as many as you can of the nine elements that may be found making up the welding symbol.
6. How can you learn to read weld and welding symbols?
7. Name the type of arc or gas weld represented by the following basic symbols:

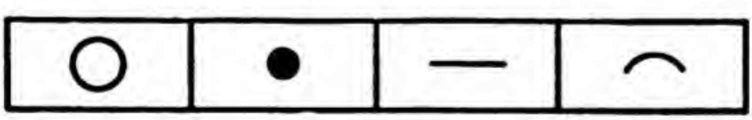
a b c d e f g h

8. Name the type of resistance weld represented by the following basic symbols:



a b c d

9. Name the following supplementary symbols used in connection with weld symbols:



a b c d

CHAPTER 12

ARCHITECTURAL AND STRUCTURAL DRAWINGS

ARCHITECTURAL WORKING DRAWINGS

Architectural drawings consist of preliminary studies, presentation drawings, and working drawings. In this book we consider only in brief some of the common aspects of working drawings. As a Navy man you won't be concerned with the design and sale of buildings; but as a technician using blueprints you may have cause to interpret and apply certain architectural conventions and symbols.

Working drawings include PLANS, ELEVATIONS, SECTIONS, DETAIL DRAWINGS, and SPECIAL FEATURES.

PLANS.—The SITE PLAN gives the salient features of a building site, the property line, contours, utilities (water, gas, sewer, electricity), location of trees, and other features. A FLOOR PLAN is a horizontal section which not only shows the floor but cuts across the walls in such a way as to show the doors, windows, partition walls, beams, outlets, and many similar installations. It might be said that a floor plan shows everything between one floor and the next one.

ELEVATIONS.—An elevation shows the front, side or rear view of a structure. It is a vertical projection and gives the floor heights, openings, and the exterior features of the building.

SECTIONS.—Sections are interior views, used to show interior construction and architectural treatment.

DETAIL DRAWINGS.—Detail drawings are, as the name implies, larger-scale drawings illustrating the detailed construction of the various parts of a structure.

SPECIAL FEATURES.—Many parts used in building construction are manufactured as unit pieces by specialized firms. For example, ventilating fans, stock stairs, and railings come in certain sizes and designs. When these are used in a building, the architect draws his plans to allow for the stock sizes and designs. Then the blueprints provided by the manufacturer are used in connection with such special equipment.

ARCHITECTURAL SYMBOLS

For the most part, the same electrical, mechanical, and piping symbols described or referenced in the earlier chapters of this book are used in architectural prints. Here some of the specific architectural symbols agreed on for combined military use are shown; and at the end of this chapter some of the materials symbols, also approved for use by the Armed Forces, are illustrated.

STRUCTURAL DRAWINGS

Structural drawings usually consist of some or all of the following elements:

GENERAL PLAN.—The general plan locates and gives the general features of the structure and the ground upon which it is situated. It includes the necessary data for designing the substructure and superstructure.

STRESS DIAGRAM.—The stress diagram shows the main dimensions, the loadings, stresses, and sizes of the members of the structure.

SHOP DRAWING.—A shop or detail drawing shows the details of the steel-and-iron work and of the timber, masonry, and concrete work.

FOUNDATION OR MASONRY PLAN.—The foundation or masonry plan covers the detail of the foundations, walls, piers, etc.

ERECTION DIAGRAM.—The erection diagram identifies and locates the various members in such a way as to help the erector in the field. For example, the approximate weight of the heavy pieces, the shipping marks, the number

of pieces, and any other helpful data will be supplied on the erection diagram.

FALSEWORK PLAN.—For difficult or important work, plans for falsework, travelers, derricks, etc., may be worked out and supplied in advance.

BILLS OF MATERIAL.—Bills of material show the different parts of the structure, markings, and shipping weight. These bills serve as check-off lists to insure that the proper materials are on hand.

RIVET LIST.—The rivet list provides the dimensions and the number of the rivets, spikes, etc., used in the structure.

LIST OF DRAWINGS.—Since so many drawings are required for any sort of sizable structure, a complete list is usually supplied within each set of drawings for the structure. This indexes the set and provides the number and title of each drawing in a logical sequence.

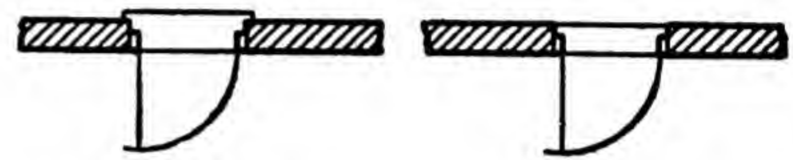
The remainder of the chapter includes illustrations of symbols used in specific types of construction.

DOOR SYMBOLS

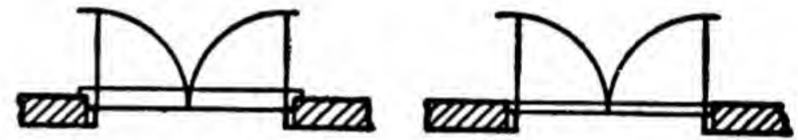
Type | *Symbol*

Single-swing with threshold in exterior masonry wall

Single door, opening in

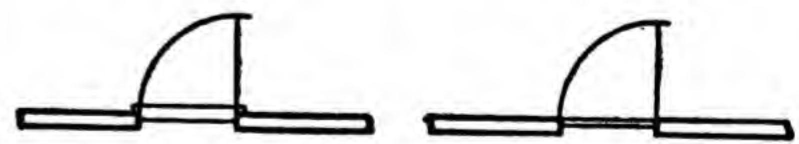


Double door, opening out



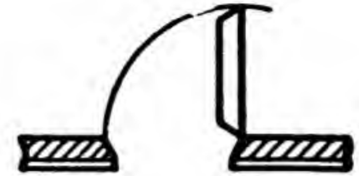
Single-swing with threshold in interior frame wall

Single door, opening out



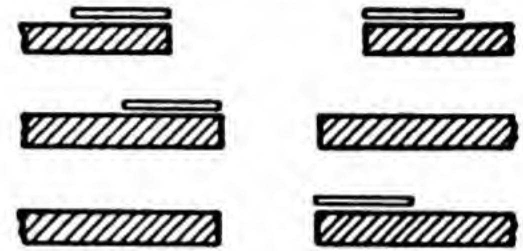
Double door, opening in

Refrigerator door

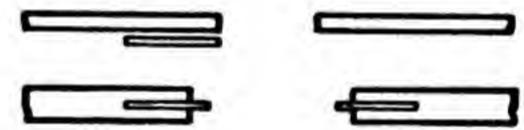


Sliding doors

In masonry walls

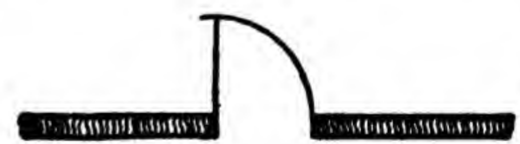


In frame walls

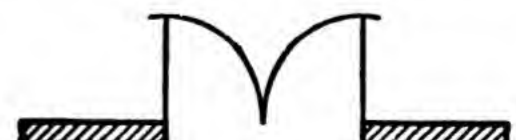


Single-swing, in interior masonry partition

Single door

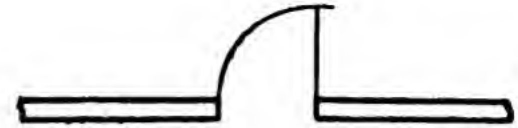


Double door



Single-swing, in interior frame partition

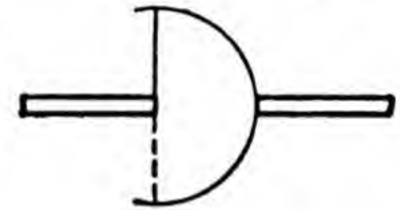
Single door



Double door

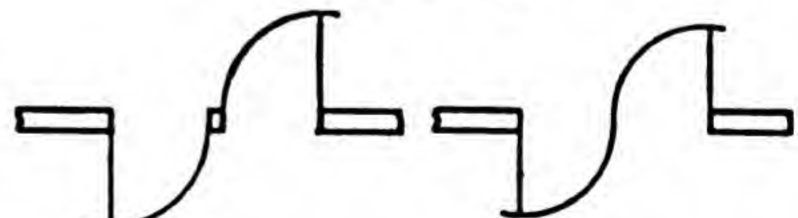
Double-acting doors

Single door



Double door

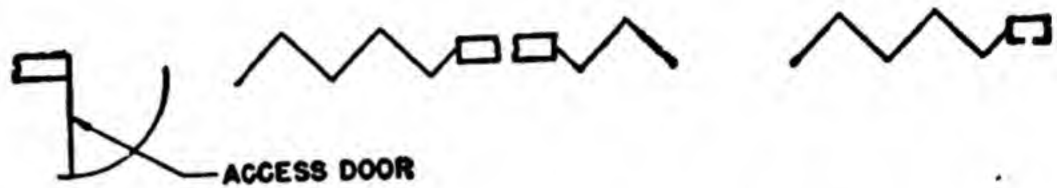
In and out doors



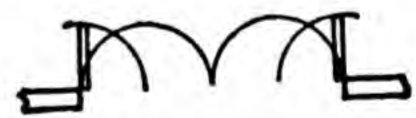
Folding door or folding partition

End hung

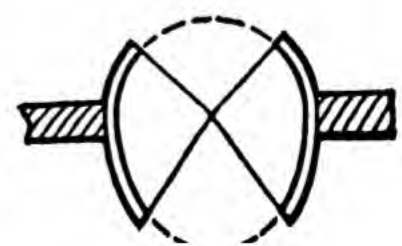
Center hung



Double-leaf door



Revolving door



WINDOW SYMBOLS

Windows in plan

Type

Double hung

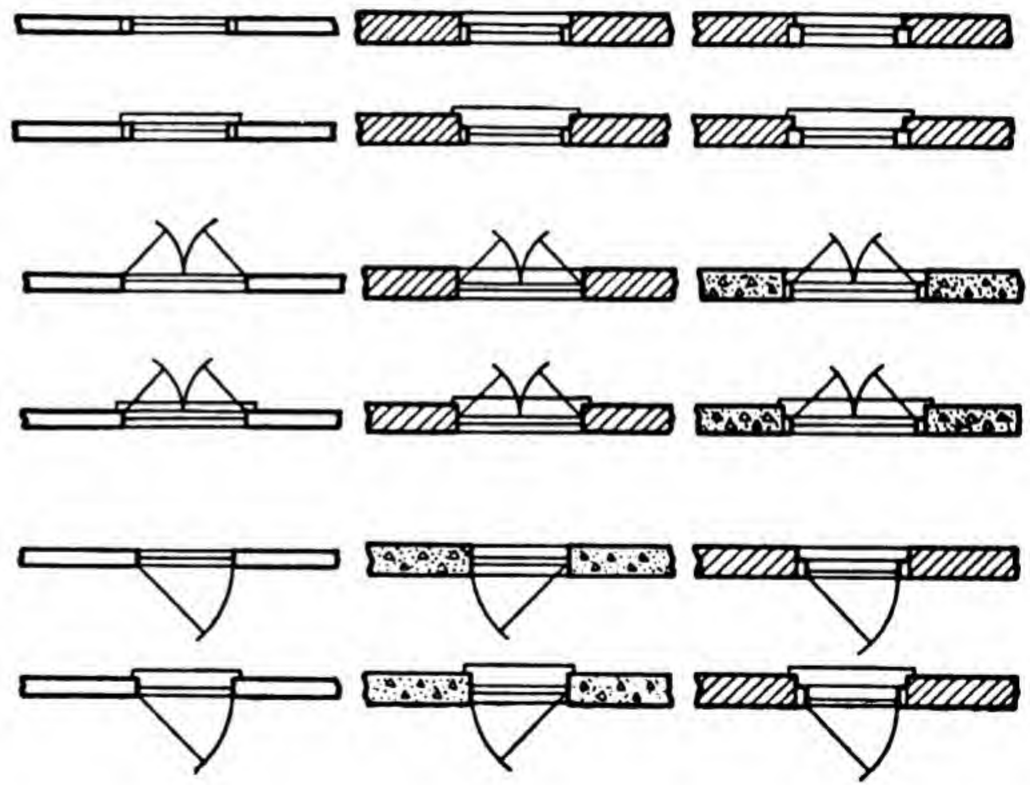
Casement

Double, opening out

Single, opening in

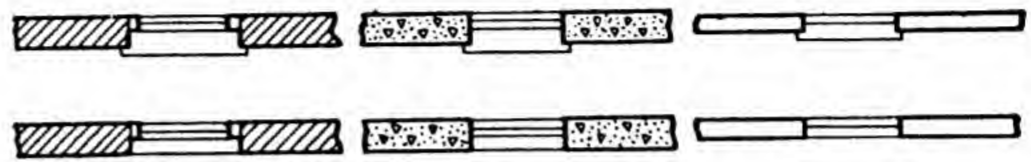
Symbol

Wood or metal sash in frame wall | *Metal sash in masonry wall* | *Wood sash in masonry wall*

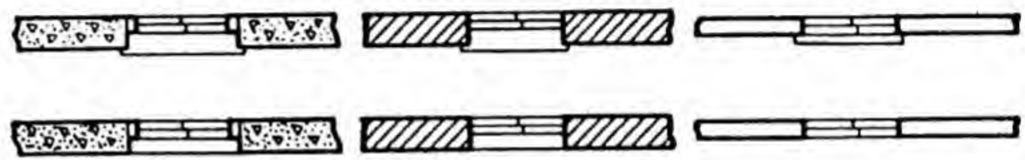


Horizontal-sliding sash

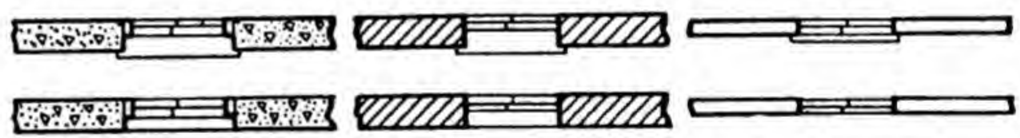
Right sash over left



Left sash over right



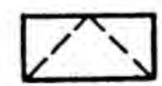
Pivoted and vented (Indicate pivoting and direction of venting on elevation.)



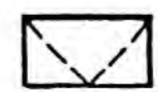
Venting of windows in elevation

Type | *Symbol*

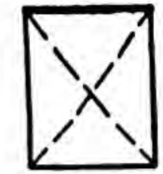
Top hinged, projected out



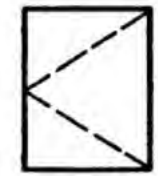
Bottom hinged, projected in



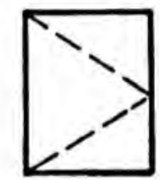
Pivoted, horizontal



Hinged, left side



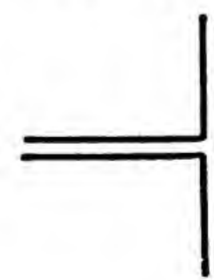
Hinged, right side



MISCELLANEOUS SYMBOLS

Item — *Symbol*

Stud partition, unless otherwise noted



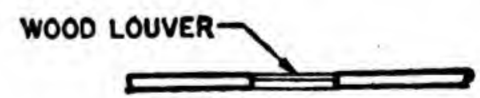
Elevators, hatchways, openings in floor, ducts, etc.

Louvered openings in masonry wall

Wood louver

Metal louver

Louvered opening in frame wall



SYMBOLS FOR GENERAL USE

Description	*Symbol*	*Illustrated use*
Tensile stress in a member	+	+59,000
Compressive stress in a member	−	−64,000
Pounds	#	120,000#
Kip (1000#)	K	30K
Feet	'	3'-6"
Inches	"	
Angular measurements		
Degrees	°	12° 36' 50"
Minutes	'	
Seconds	"	
Deflection	Δ	Δ = 0.300"
Modulus of elasticity	E	E = 30,000,000
At	@	4@6

Percent	%	20%
By	X	3X10
Round	ϕ	$1\frac{1}{2}\phi$
Square	□	2□
Structural framing, member designations (Followed by member number, and preceded by floor designation* where applicable)		
Beam	B	2B2
Girder	G	BG4
Joist	J	RJ6
Slab	S	4S8
Column	C	C10
Bracing	Br	Br12
Strut	St	St3

*Floor designation by number, with B for basement and R for roof.

Footing	F	F5
Girt	Gt	Gt7
Knee brace	KB	KB9
Lintel	L	L11
Purlin	P	P2
Rafter	R	R4
Stair stringer	SS	SS6
Truss	T	T8
Wall	W	W10

REINFORCED CONCRETE CONSTRUCTION

The following symbols are for use on drawings of reinforced concrete structures or elements thereof.

Description	*Symbol*
Bars, round or square*	
Straight bars	
Plain ends	———

*For bar designation the symbols for round and square need not be used except in those cases where the same size bars are made in both rounds and squares, as in the case of the one-inch bar. In most cases the inch symbol can also be omitted without confusion.

Hooked one end

Hooked both ends

Bent bars

Plain ends

Hooked one end

Hooked both ends

Column ties

Square or rectangular

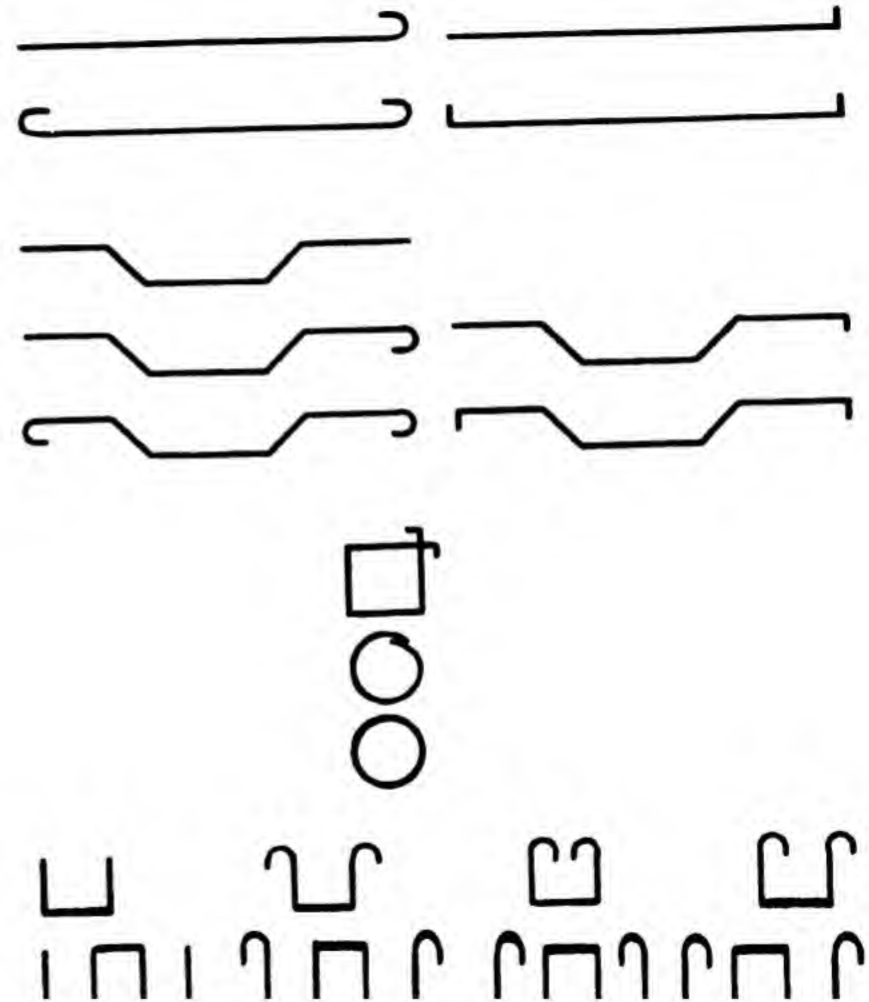
Circular

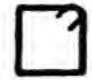
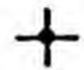
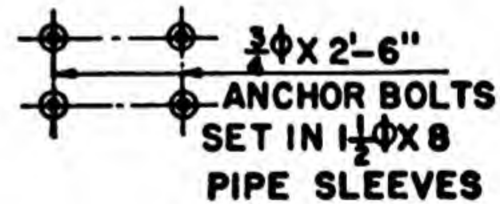
Column spiral

Stirrup

"U" type

"W" type



Description	*Symbol*	*Illustrated use*
Tied type		
Direction in which main bars extend		
Limits of area covered by bars		
Anchor bolt (in plan)		
Anchor bolt set in pipe sleeve (in plan)		
Ultimate compressive strength of concrete	f'_c	f'_c = 3000 PSI
Tensile stress in reinforcement	f_s	f_s = 20,000 PSI

Compressive stress in concrete	f_c	$f_c = 1050$ PSI
Area of tensile reinforcement	A_s	$A_s = 2.4$ SQ IN.
Area of compressive reinforcement	A'_s	$A'_s = 1.8$ SQ IN.
Modulus of elasticity of concrete	E_c	$E_c = 1{,}500{,}000$ PSI
Modulus of elasticity of reinforcement steel	E_s	$E_s = 30{,}000{,}000$ PSI

STRUCTURAL STEEL AND ALUMINUM CONSTRUCTION

The following symbols are for use on drawings involving structural steel or aluminum construction. When both aluminum and structural steel shapes occur on the same drawing, add suffix "AL" to all aluminum shape designations; for example 8 ⊔ 6.67 AL.

Description	*Symbol*	*Illustrated use*
Gage	g	$g = 3\frac{1}{2}$
Pitch of rivets	P	$P = 2\frac{1}{2}$
Milled face	MILL	

Wide flange shape	WF	24 WF 76
Beams		
American standard	I	15 I 42.9
Light beams and joists	B	6 B 12
Standard mill	M	8 M 17
Junior	Jr	7 Jr 5.5
Light columns	M	8X8 M 34.3
Channels*		
American standard	⊔	9 ⊔ 13.4
Car and ship	⊔	12X4 ⊔ 44.5
Junior	Jr ⊔	10 Jr ⊔ 8.4
Angles*		
Equal leg	L	L 3X3X $\frac{1}{4}$

*Symbols for channels and angles may be oriented to agree with the position of the member being designated.

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Unequal leg	L	L 7X4X$\frac{1}{2}$
Bulb	BULB L	BULB L 6X3$\frac{1}{2}$X17.4
Serrated (cut from channel)**	⊥	⊥ (3+1) ⊔ 4.1
Tees		
Structural, cut from rolled shapes	ST	ST 5 WF 10.5
		ST 6 I 20.4
		ST 6 B 9.5
		ST 6 Jr 5.90
Rolled (flange by stem)	T	T 4X3X9.2
Built up	T	T BAR 3X$\frac{1}{2}$ BAR 4X$\frac{1}{4}$
Serrated (cut from beam)**	T	T (4+1) WF 10
Bearing pile	BP	14BP73

**In example given under illustrated use, the sum of the figures within the parentheses is the depth of the stem, the first figure being one-half the depth of the cut shape and the second being one-half the depth of serration.

Zee	Z	Z6×3$\frac{1}{2}$×15.7
Plate	Pl	Pl 18×$\frac{1}{2}$×2'–6"
Plate (alternative use)	Pl	10.2# Pl
Checkered plate	CkPl ·	CkPl $\frac{1}{2}$
Flat bar	Bar	Bar 2$\frac{1}{2}$×$\frac{1}{4}$
Tie rod	TR	$\frac{3}{4}$ϕ TR
Pipe column	O	O6ϕ

COMBINATIONS OF STRUCTURAL SHAPES

Except for those shapes for which the symbol is a letter or letters, symbols for single structural shapes may be combined to indicate the composition of a built up member. For instance a double-angle strut may be represented thus ┐┌ ; and a channel and angle section may be represented by]┌ . Where a combination includes a shape the symbol for which is a letter or letters, a line representation of the shape may be used, as for instance in the case of a wide flange beam and a channel, the representation may be thus ⊤̄ . The representation in each case may be accompanied by the sizes of the shapes, involved, thus 24 WF 100 / 2 Pl 14×$\frac{3}{4}$.

RIVETING SYMBOLS

Description	Symbol: Plan	Symbol: Section
Shop rivets		
Two full heads		
Countersunk & chipped NS[1]		
Countersunk & chipped FS[2]		
Countersunk & chipped BS[3]		
Countersunk, not over $\frac{1}{8}$ inch high NS		
Countersunk, not over $\frac{1}{8}$ inch high FS		
Countersunk, not over $\frac{1}{8}$ inch high BS		

Flattened to $\frac{1}{4}$ inch for $\frac{1}{2}$ and $\frac{5}{8}$ rivets NS

Flattened to $\frac{1}{4}$ inch for $\frac{1}{2}$ and $\frac{5}{8}$ rivets FS

Flattened to $\frac{1}{4}$ inch for $\frac{1}{2}$ and $\frac{5}{8}$ rivets BS

Flattened to $\frac{3}{8}$ inch for $\frac{3}{4}$ and over rivets NS

Flattened to $\frac{3}{8}$ inch for $\frac{3}{4}$ and over rivets FS

Flattened to $\frac{3}{8}$ inch for $\frac{3}{4}$ and over rivets BS

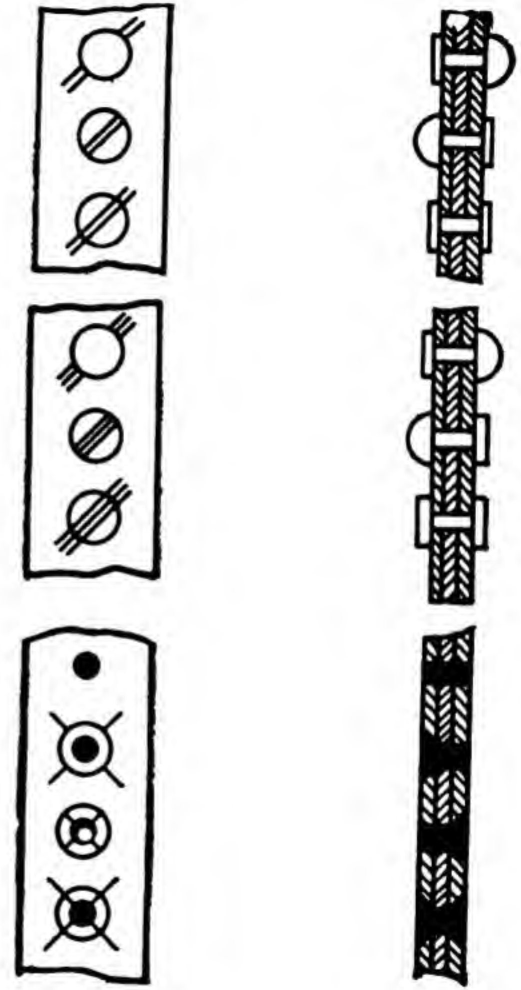
Field rivets

Two full heads

Countersunk NS

Countersunk FS

Countersunk BS



TIMBER CONSTRUCTION

The following symbols are for use on drawings involving timber construction.

Description	*Symbol*	*Illustrated use*
Horizontal shearing stress	H	H=120PSI
Compressive stress perpendicular to grain	$\underline{c\perp}$	$\underline{c\perp}$=455PSI
Compressive stress parallel to grain	c	c=1450PSI
Stress in extreme fibre for bending	f	f=1450PSI
Tensile stress parallel to grain	t	t=1450PSI

TIMBER CONNECTORS

Split ring	SR	$2\frac{1}{2}$SR
Toothed ring	TR	2TR

Claw plate; male	CPM	$2\frac{5}{8}$ CPM
Claw plate; female	CPF	$3\frac{1}{8}$ CPF
Shear plate	SP	4SP
Bulldog; round	BR	$3\frac{3}{4}$ BR
Bulldog; square	BS	5BS
Circular spike	CS	$3\frac{1}{8}$ CS
Clamping plate; plain	CPP	5X5CPP
Clamping plate; flanged	CPFL	5X8CPFL
Spike grid; flat	SGF	$4\frac{1}{8}$X$4\frac{1}{8}$ SGF
Spike grid; single curve	SGSC	$4\frac{1}{8}$X$4\frac{1}{8}$ SGSC
Spike grid; double curve	SGDC	$4\frac{1}{8}$X$4\frac{1}{8}$ SGDC

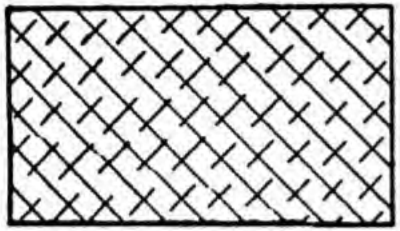
IDENTIFICATION OF TIMBERS FOR SPECIAL GRADING

Where special grading provisions must be used for certain members because of the design conditions, such members may be designated with the following symbols:

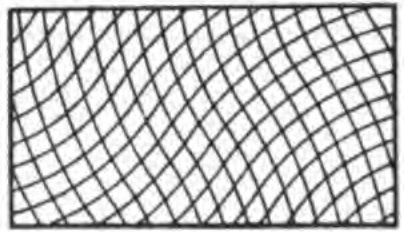
Description	*Symbol*
Joists and planks or beams and stringer grades	
Beams, continuous over 2 spans	M
Beams, continuous over 3 or more spans	N
Members in tension, or in compression parallel to grain, or in combined compression and bending	T
Post and timber grades	
Special size members not conforming to standard post and timber classification sizes	P

MATERIAL SYMBOLS

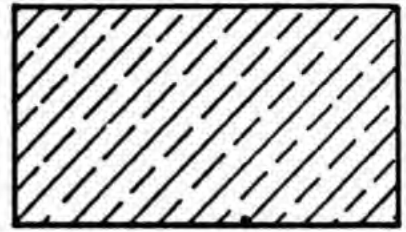
(See chapter 3, figure 3–10, for the simplified section conventions which are preferred wherever practicable.)



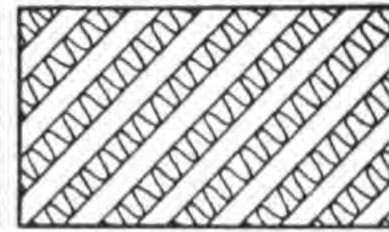
Aluminum, magnesium, and their alloys



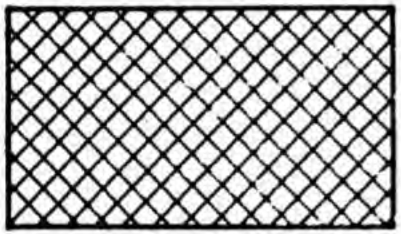
Asphalt



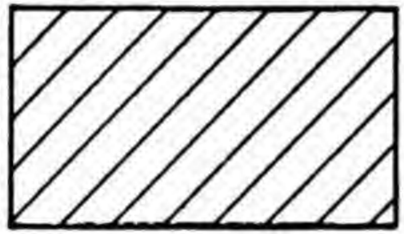
Copper, brass, bronze, and their compositions



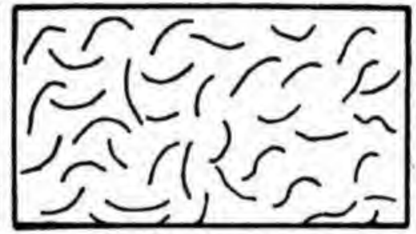
Asbestos, magnesia, filler packings, and similar materials



Babbitt, lead, solder, bearing metals and white metals



Brick

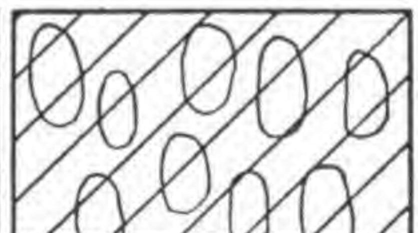


Felt and leather (natural)

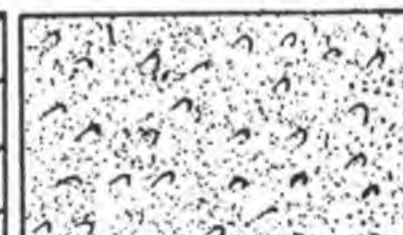
Cut stone

Coal

Fabric and flexible material

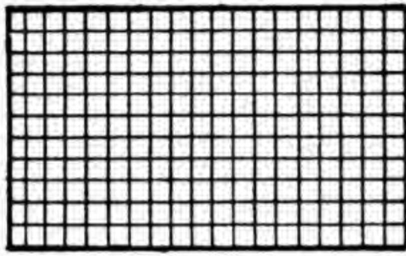


Cork

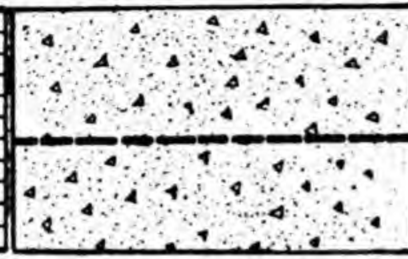


Cinder block

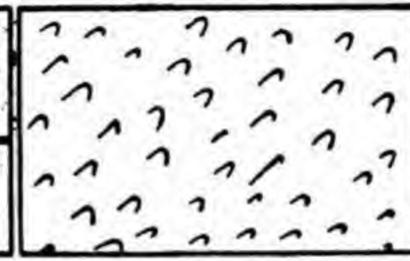
MATERIAL SYMBOLS (Continued)



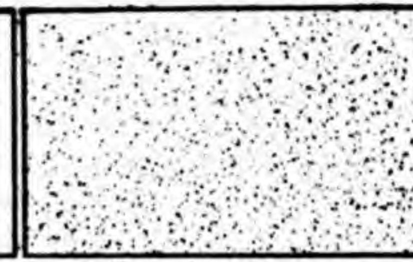
Electrical windings, electrical magnets and resistances, etc.



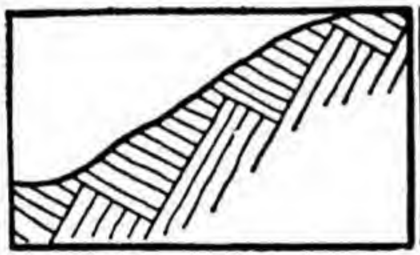
Reinforced concrete



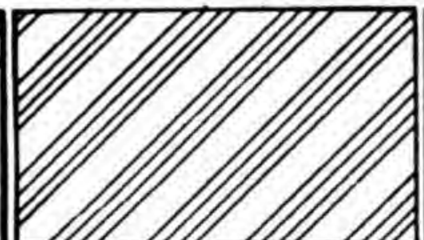
Cinders



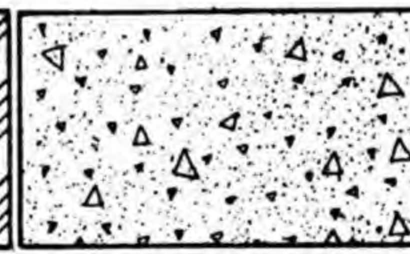
Cement and plaster



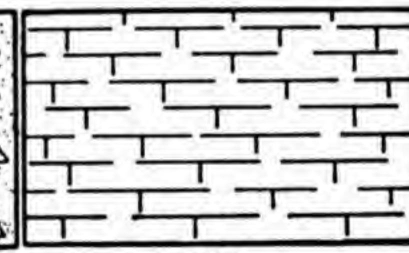
Earth



Electrical insulation

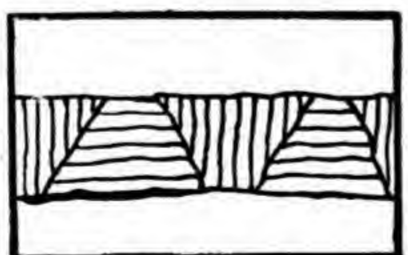


Concrete and concrete block



Chalk

Container board

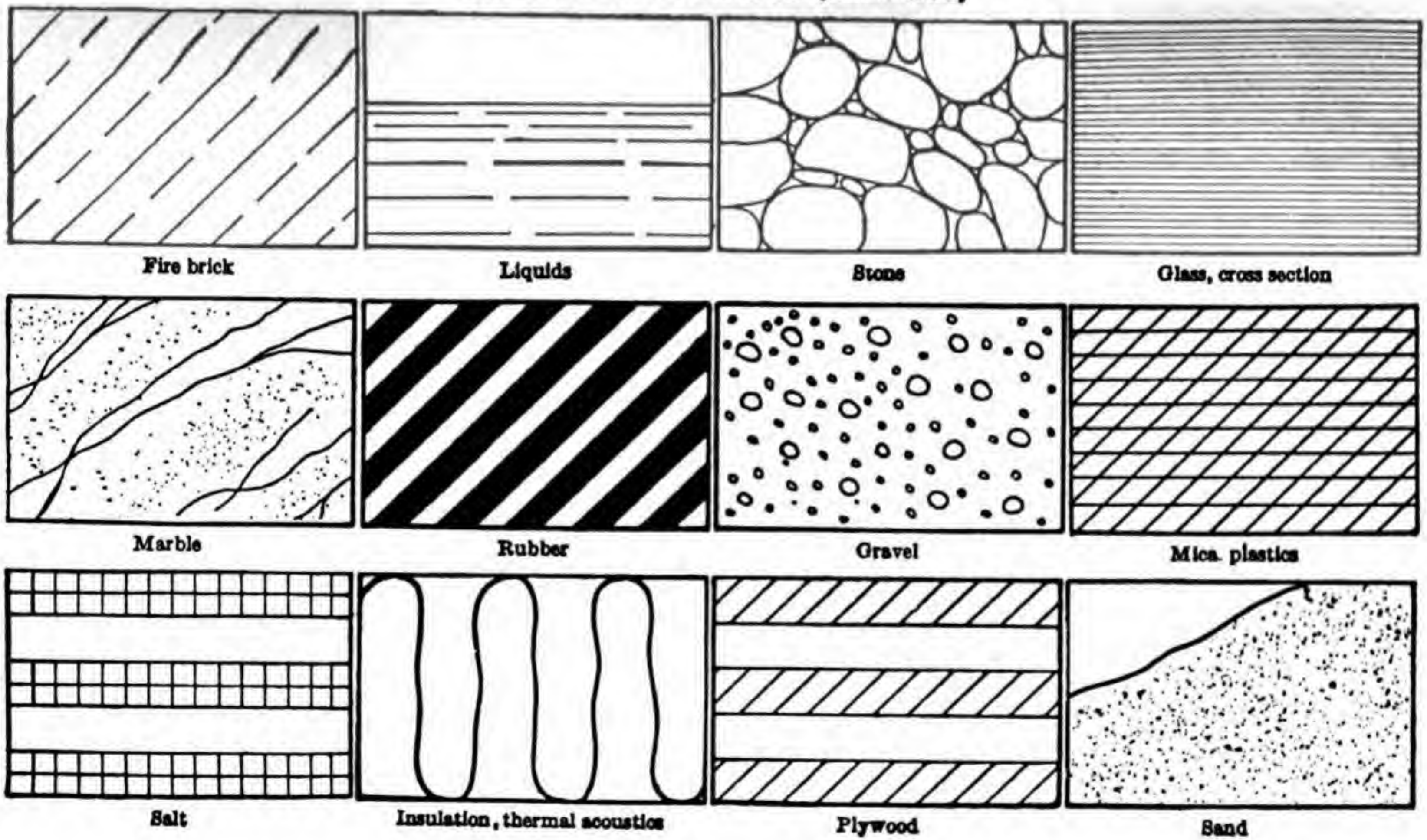


Rock

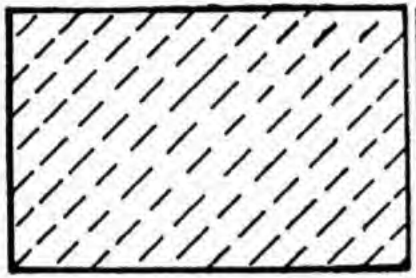
Wood: 1, with grain; 2, cross grain; 3, blocking

Composition and mastic

MATERIAL SYMBOLS (Continued)

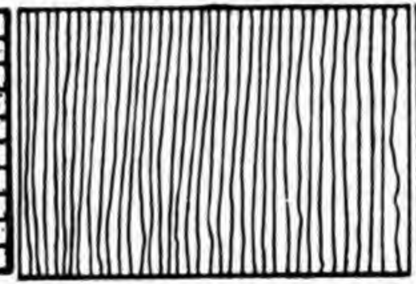


MATERIAL SYMBOLS (Continued)

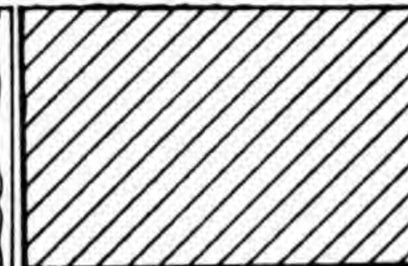


Porcelain

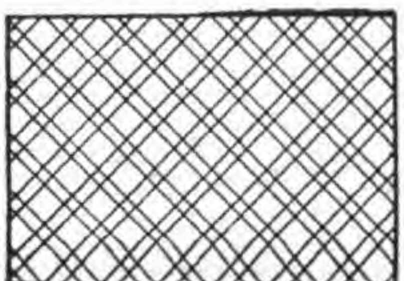
Slate



Tile, structural; ceramic, structural; facing, etc.

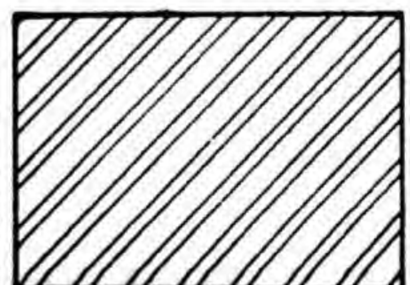


Iron, including cast iron, malleable iron

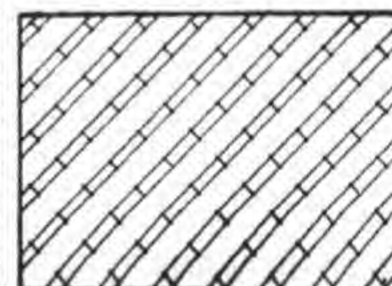


Zinc

Tin

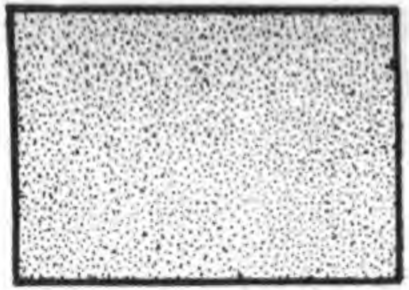


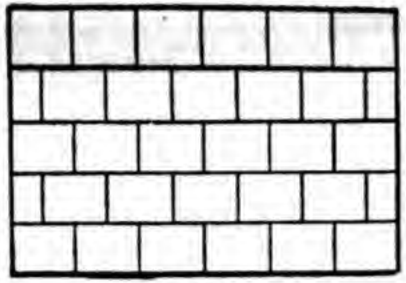
Steel and wrought iron

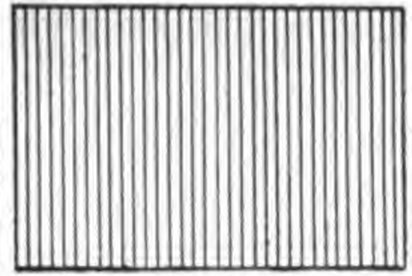


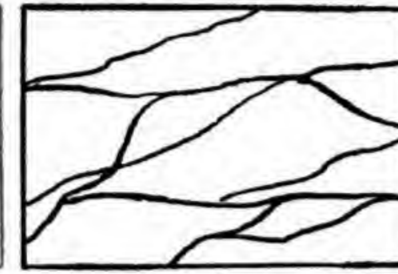
Special alloys

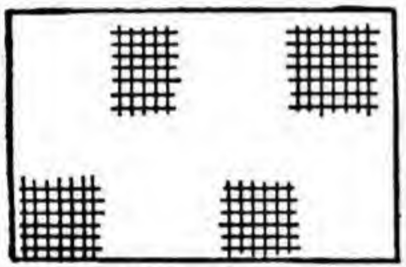
EXTERIOR MATERIAL SYMBOLS

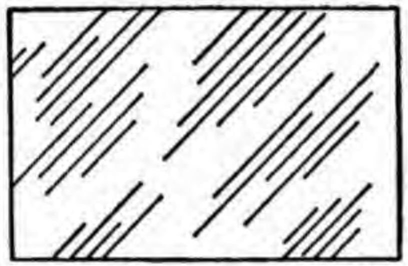

Concrete, stucco, plaster

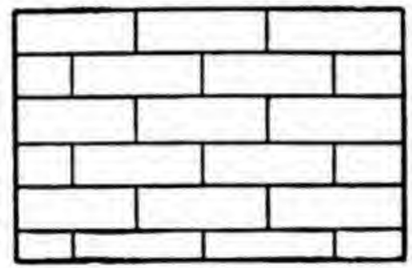

T C tile

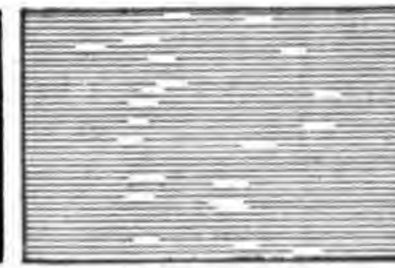

Roofing tile

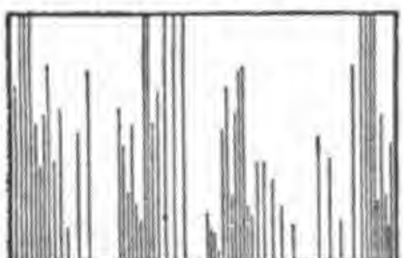

Marble

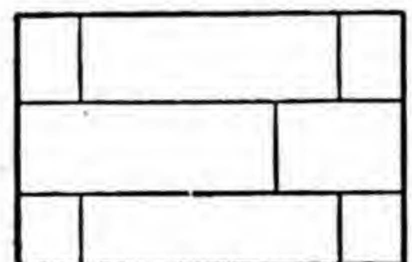

Wire mesh


Glass and transparent material


Brick


Brick, small scale


Metal


Concrete block, cinder block

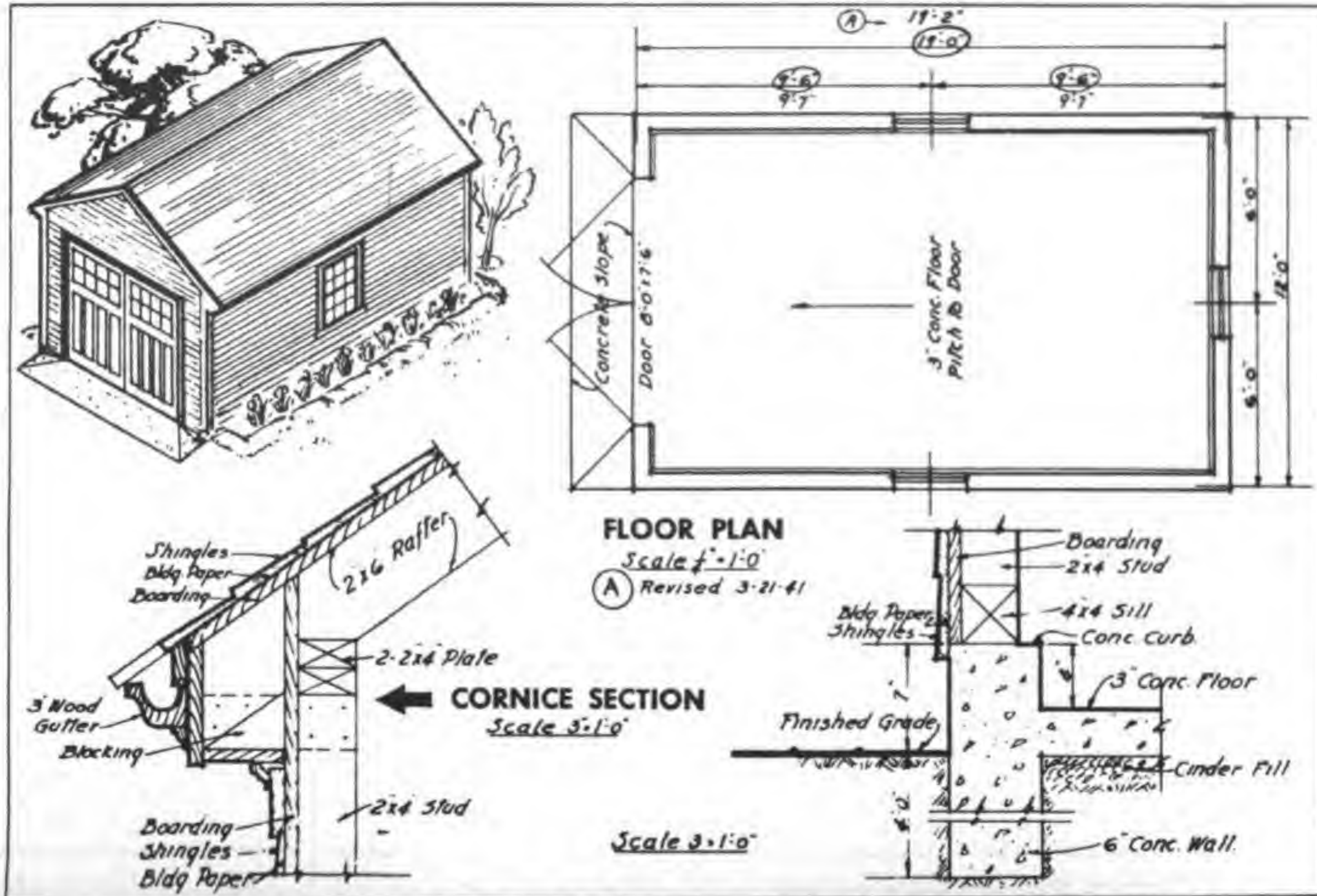


Figure [illegible] — Wooden garage. Courtesy of McGraw-Hill Book Co., Inc.

QUIZ

1. Into what three classifications may "architectural drawings" be placed?
2. Into what five categories or types of drawings are working drawings further divided?
3. What do the plans include?
4. What does an elevation include?
5. What does a section show?
6. What are detail drawings?
7. What are special features?
8. Structural drawings usually consist of some or all of the following elements with which you should be familiar. Describe each briefly.
   a. General plan.
   b. Stress diagram.
   c. Shop drawing.
   d. Foundation or masonry plan.
   e. Erection diagram.
   f. Falsework plan.
   g. Bills of material.
   h. Rivet list.
   i. List of drawings.

To answer the following questions, refer to the working drawing for a wooden garage appearing at the end of Chapter 12.

9. What is the outside width of the garage measured on the foundation?
10. What does the letter "A" in the circle mean beside the 19′−0″ dimension which is also circled?
11. What is the outside length of the garage measured on the foundation?
12. What are the inside dimensions of the garage measured on the floor and within the concrete wall?
13. How thick is the floor?
14. How deep does the concrete wall go down in the ground?
15. What size are the studs and by what are they supported?
16. On what do the rafters rest?

17. What provision is indicated on the drawing for water drainage when a car is washed?
18. What precaution is taken, in addition to the shingles, to waterproof the roof and walls?
19. Where in the length of the walls are the windows located?
20. What size lumber is used for the rafters?
21. Where on the drawing do you see that the rafters are notched where they rest on the plate?
22. What provision is made for water runoff from the roof?
23. Is the concrete poured right on the ground when construction is begun?

APPENDIX I

ANSWERS TO QUIZZES

CHAPTER 1

Making and Handling Blueprints

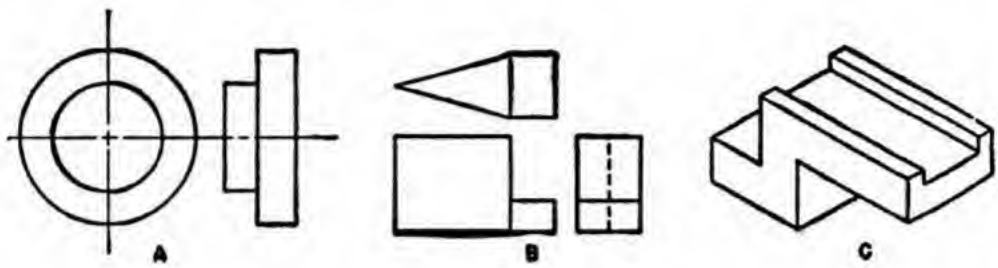
1. Unit assembly.
2. Protect them from dampness, grease, and strong sunlight.
3. Distance should never be measured on a blueprint because of three possible sources of error:
   Original inaccuracy of draftsman's work.
   Stretching or shrinking during the blueprinting process.
   Stretching or shrinking due to changes in temperature and humidity.
4. To expedite the locating of blueprints in the standard filing system the Navy uses for blueprints.
5. Ammonia prints, or "ozalids" as they are usually called.
6. Block off the light where they are.
7. Negative.
8. None.
9. Turns exposed areas blue.
10. Any number.
11. White, dark.
12. Dark, light, more copies are needed.
13. From a negative photostat.
14. The Ozalid process.

CHAPTER 2

Blueprint Views

1. The photograph is not accurate. It does not show true shape or size.
2. Location of parts and their relationship to other parts.
3. The lines of the isometric representing the horizontal and vertical lines of the object are true in length.
4. Mechanical perspectives are used to provide pictures of objects not yet constructed.

5. They are accurate. The lines of orthographic projection views indicate the true size and shape of the object drawn.
6. An inclined or slant surface.
7.

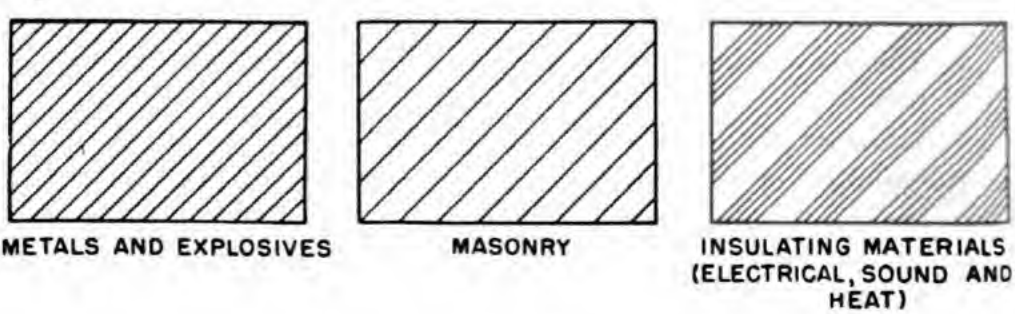


8. Foreshorten.
9. Would.
10. May.
11. Orthographic drawings.
12. Vertical.
13. 30°.
14. Perpendicular.
15. Usually three. Two if a third view would not give any more information, and four if an auxiliary is used.
16. Shape and size.

CHAPTER 3

Lines and Sections

1. The names of the lines are:
    (A) Centerline.
    (B) Outline.
    (C) Dimension line.
    (D) Extension line.
    (E) Hidden line.
2.



3. Revolved section.
4. Leader.
5. The object's shape at a certain cross section or station point.
6. A sectional view or section.
7. With diagonal, parallel lines (crosshatching) which are called section lines.
8. Cutting.
9. Offset in the cutting plane.
10. All.
11. Half.
12. Yes.
13. Outside diameter of the thread, number of threads per inch, thread series and class of thread or the "fit".
14. By the addition of "_______LH" to the other four numbers on the drawing. For example, ¼–20, NC–2LH.
15. They are not indicated but assumed if a thread is not indicated as being a left-hand thread.
16. Root diameter, pitch diameter, and outside diameter for each gear.

CHAPTER 4

Dimensions

1. a. Because each dimension is measured from the preceding dimension; each measurement is thus influenced by the errors in preceding measurements, and the total error will exceed the sum of the individual errors. On a part having many location dimensions, many individual errors may be made, and a serious total error may accumulate.
   b. By measuring each dimension in turn from the same reference edge (or line).
   c. The double error in the last dimension measured to which baseline dimensioning is always susceptible will fall in whichever dimension the draftsman leaves open.
   d. Floating dimension.
2. a. Hole: 6.5046 inches.
   Shaft: 6.4913 inches.
   b. 0.0179 inch. (Maximum diameter hole 6.5046 inches minus minimum diameter shaft 6.4867 inches.)
3. One and only one. It's your base point.
4. Tolerance.
5. Allowable minimum and maximum dimensions.

6. Minus and plus limits.
7. A few millionths of an inch.
8. To $\frac{1}{64}$ of an inch.
9. Interference.
10. Clearance.

CHAPTER 5

Title Blocks, Numbers, and Bills of Material

1. For identification during assembly and to speed up replacement of broken parts.
2. a. That the blueprint represents a fuselage ring which would be located, on an airplane, 209½ inches from zero station (nose or firewall).
   b. If a zone number for this part were shown in the title block, the desired view would be found in the general area marked by the corresponding zone number in a square along the lower border line of the blueprint.
3. In the stock size column of the title block.
4. By a letter, in a small circle near some dimension or note, or in a separate change or revision block.
5. The size of the drawing compared with the size of the part.
6. The drawing will be only 1/12th the size of the work.
7. To enlarge small parts so their dimensions and shape can be easily noted and to decrease the size of large parts for convenience in handling and storing the prints.
8. You are measuring and repeating any errors in drafting, in stretching or shrinkage of the paper, or in the reduction in size of the drawing to the size of the print. You are possibly missing the scale, are including errors due to daily changes in temperature and humidity affecting the paper, and taking a chance on making errors yourself when reading the rule while taking off the dimension.
9. A finish mark.
10. Refer to the usage block on the print.

CHAPTER 6

Technical Sketching

1. As much as is necessary to serve the purpose for which it is made
2. Military Standards for General Drawing Practice (JAN-STD-1).
3. Perspective assembly.

4. Perspective detail.
5. An orthographic assembly.
6. An orthographic detail.
7. Assembly, detail.
8. Orthographic or perspective.
9. Only what you actually see from the viewing position you have selected.
10. Select one that will show the object to its best advantage.
11. It enables you to show someone else exactly what you want him to know or do.
12. Speed of producing the finished sketch and the fact that a minimum of equipment is necessary.
13. Pencil and paper.

CHAPTER 7

Curve or Bend Allowance

1. They are taken from the bend allowance table universally used in the aircraft industry.
2. It is equal to a quarter of the circumference of a circle whose radius is equal to the bend radius (the inside radius of the curve) plus half the thickness of the metal being bent.
3. The unbent surfaces of a curved corner.
4. Mold line.
5. By a point.
6. It is stretched along the outside of the curve and compressed along the inside.
7. At points along the bend half way between the inside and outside surfaces of the metal—the neutral axis.
8. Because it does not change in length when a bend is made in the sheet.
9. The actual length of the material to be used.
10. The length or amount of material allowed for the bend.
11. The bend allowance.
12. To the inside of the metal being formed unless otherwise stated.
13. $B.\ A. = 0.0607''$.
14. a. Yes.
    b. $B.\ A. = 0.1837''$.
15. $SB = 0.050''$.

16. $SB = \frac{19}{64}''$.
Flat $A = 1\frac{13}{64}''$.
Flat $E = 1\frac{13}{64}''$.
Flat $C = 4\frac{13}{32}''$.
$B.\ A. = \frac{27}{64}''$.
Total length $= 7\frac{21}{32}''$.

CHAPTER 8

Templates

1. As a guide or pattern for making duplicate parts.
2. Because the accuracy of all the parts made from a template as a pattern will depend upon the accuracy of the template.
3. a. Make templates of sheet steel.
   b. Use scriber and dividers instead of pencil or pencil compass for all outlines except those not to be cut.
   c. Check transferred dimensions, divider settings, and scribed lines with a magnifying glass.
4. The strain on metal caused by the intersection of two or more bends.
5. Make a new template from the blueprint.
6. A transfer punch.
7. It fits the punched locating hole in the template and when struck with a hammer, makes a center punch mark on the work beneath the template.
8. Shear.
9. Punch a hole or shear a small radius.
10. To provide a "handle" for a small template and help to keep it from being mislaid.
11. On the tab.

CHAPTER 9

Electrical and Electronic Prints

1. a. To prevent a print from being too large for effective use.
   b. To provide more legibility by not jamming the information too close together.
2. Elementary, isometric, wiring plans and schematics.
3. So that all naval blueprints, regardless of the developing activity, are easily understood by all users.
4. Lowest to highest, forward to aft, starboard to port.
5. A, B, C.

6. Vital, semivital and nonvital;
   Red, yellow and gray.
7. Forward switchboard feeders have odd numbers for identification; after switchboard feeders have even numbers for identification.
8. Increasing numbers of electrical equipment aboard ships made the 1949 system cumbersome and ambiguous in identification data.
9. Elementary.
10. Schematic.
11. Wiring deck plan.

CHAPTER 10

Mechanical and Piping Symbols

1. Sketches of the actual components.
2. a. When the gear is not too complicated.
   b. When there are not too many components to be shown.
   c. When the reader will understand simple pictures better than he will symbols.
3. Bevel gears.
4. a. Mechanical energy.
   b. Electrical energy.
5. To show how standard mechanical units are mechanically interconnected.
6. No, they do not.
7. To indicate direction of flow.
8. With labels on the diagram beside the component.
9. To identify symbols used in the diagram.
10. Mil-Std-17.
11. Time and space on the diagram.
12. By using them in making and reading diagrams.
13. a.

    b. 

    c.

    d.

    e.

    f.

14. Draw the symbols for the following common pipe lines:

a. Acetylene.	——— AC ———
b. Compressed air.	——— A ———
c. Fuel supply (except gasoline).	——— FUEL ———
d. Gasoline.	——— GASO ———
e. Oxygen.	——— OX ———
f. Water, fresh.	——— FW ———
g. Water, salt.	——— SW ———
h. Water, hot.	—— - - —— - - —— - - ——
i. Water, cold.	—— - —— - —— - —— - ——
j. Carbon dioxide system.	——— CO_2 ———
k. Fire line.	——— F ———
l. Foam solution.	——— FOAM ———

CHAPTER 11

Welding Symbols

1. The welding symbol. It contains the weld symbol and up to seven more elements of information.
2. The tail of the welding symbol contains the necessary process or specification reference.
3. On the side of the reference line toward the reader.
4. They resemble in shape to a great extent the types of welds which they represent.
5. Reference line; arrow; basic weld symbols; dimensions and other data; supplementary symbols; finish symbol; tail; specifications, process, or other reference.
6. By studying the rules and illustrations and checking yourself out by reading prints.
7. a. Bead.
   b. Fillet.
   c. Plug or slot.
   d. Square groove.
   e. V-groove.
   f. Bevel groove.
   g. U-groove.
   h. J-groove.
8. a. Spot.
   b. Projection.
   c. Seam.
   d. Flash or upset.
9. a. Weld all around.
   b. Field weld.
   c. Flush-contour weld.
   d. Convex-contour weld.

CHAPTER 12

Architectural and Structural Drawings

1. a. Preliminary studies. These are usually brief sketches to give a general idea of a structure.
   b. Presentation drawings. These are more complete and probably are mechanical drawings with major dimensions and general information.
   c. Working drawings. These are always mechanical drawings, have complete dimensions given, include specific information, and give all the information necessary for the construction of the structure.

2. Plans, elevations, sections, detail drawings, and special features.
3. a. Site plans showing salient features of the building site, property, line, contours, utilities (water, gas, sewer, electricity), location of trees, and other features.
   b. Floor plan. a horizontal section which shows the door and cuts across the walls so as to show doors, windows, partition walls, beams, outlets, and similar installations.
4. Front, side, or rear view of a structure, giving floor heights, openings, and exterior features of the buildings.
5. An interior view of interior construction and architectural treatment.
6. Larger-scale drawings illustrating detailed construction of parts of a structure.
7. Commercial items such as fans, stock stairs, and so forth, that are available in certain sizes and designs. The manufacturer furnishes blueprints of his items from which plans are drawn to accommodate these items in the structure.
8. a. GENERAL PLAN.—The general plan locates and gives the general features of the structure and the ground upon which it is situated. It includes the necessary data for designing the substructure and superstructure.
   b. STRESS DIAGRAM.—The stress diagram shows the main dimensions, the loadings, stresses, and sizes of the members of the structure.
   c. SHOP DRAWING.—A shop or detail drawing shows the details of the steel-and-iron work and of the timber, masonry, and concrete work.
   d. FOUNDATION OR MASONRY PLAN.—The foundation or masonry plan covers the detail of the foundations, walls, piers, etc.
   e. ERECTION DIAGRAM.—The erection diagram identifies and locates the various members in such a way as to help the erector in the field. For example, the approximate weight of the heavy pieces, the shipping marks, the number of pieces, and any other helpful data will be supplied on the erection diagram.
   f. FALSEWORK PLAN.—For difficult or important work, plans for falsework, travelers, derricks, etc., may be worked out and supplied in advance.
   g. BILLS OF MATERIAL.—Bills of material show the different parts of the structure, markings, and shipping weight. These bills serve as check-off lists to insure that the proper materials are on hand.
   h. RIVET LIST.—The rivet list provides the dimensions and the number of the rivets, spikes, etc., used in the structure.

i. List of drawings.—Since so many drawings are required for any sort of sizable structure, it is customary to include with each set a List of Drawings. This list, included as one of the first pages in the set, will identify each drawing by name so that it can be quickly located in the set.

9. 12 feet 0 inches.
10. The "A" indicates that the drawing has been revised. The old dimension is circled and superseded by the dimension at the circled letter "A".
11. 19 feet 2 inches.
12. 11 feet 0 inches by 18 feet 2 inches.
13. 3 inches.
14. 4 feet 0 inches.
15. 2 x 4 studs on a 4 x 4 sill.
16. On a double 2 x 4 plate.
17. The 3-inch concrete floor is pitched toward the door.
18. They are covered with building paper before the shingles are applied.
19. In the middle.
20. Two by sixes.
21. In the cornice section.
22. Wooden gutters are installed.
23. No, there is an inch or so of cinder fill to provide water drainage and a good base for the concrete.

APPENDIX II

STANDARD ABBREVIATIONS USED ON BLUEPRINTS

Accessory	ACCESS
Acetylene	ACET
Accumulate	ACCUM
Acidproof	AP
Addendum	ADD
Adjust	ADJ
Advance	ADV
Aerodynamic	AERODYN
Aeronautical	AERO
Aileron	AIL
Airborne	ABN
Air-break switch	ABRSW
Aircraft	ACFT
Aircraft Industries Association	AIA
Air escape	AE
Airtight	AT
Alarm	ALM
Alternating current	AC
Altimeter	ALTM
Altitude	ALT
Aluminum	Al
American Institute of Architects	AIA
American Society of Aeronautical Engineers	ASAE
American Society of Civil Engineers	ASCE
American Society of Engineers and Architects	ASEA
American Society of Mechanical Engineers	ASME
American Society for Metals	ASM
American Standards Association	ASA
American Steel and Wire Gage	ASWG
American Telephone and Telegraph Company	AT&TCO
American War Standards	AWS
American Welding Society	AWS
American Wire gage	AWG
Ammeter	AM
Ammunition	AMM
Amount	AMT
Ampere	AMP
Amplifier	AMPL
Amplitude modulation	AM
Angle stop valve	ASV
Annealed	ANLD
Annunciator	ANN.
Anode	A
Anodize	ANOD

Antenna	ANT
Antifriction bearing	AFB
Antifriction Bearing Manufacturers Association	AFBMA
Antifriction metal	AFM
Apartment	APT.
Apparatus	APP
Appendix	APPX
Application	APPL
Approved	APPD
Approximate	APPROX
Architecture	ARCH.
Arc weld	ARC/W
Area drain	AD
Armament	ARMT
Armature	ARM
Armored	ARMD
Armor piercing	AP
Armor plate	ARM-PL
Army-Navy	AN.
Arrangement	ARRGT
Arresting (gear or hook)	ARREST.
Arrestor	ARR
Asbestos	ASB
Asphalt	ASPH
Asphalt roof shingles	ASPHRS
Asphalt-tile floor	ATF
Assembly	ASSY
Assigned	ASGD
Assistant	ASST
Association	ASSN
Atmosphere	ATM
Atomic	AT
Atomic hydrogen weld	AT/W
Attach	ATT
Audible	AUD
Audio frequency	AF
Authorize	AUTH
Automatic	AUTO
Automatic door seal	ADS
Automatic sprinkler	AS
Automatic sprinkler riser	ASR
Automatic stop and check valve	AUTO S & CV
Auxiliary	AUX
Avenue	AVE
Average	AVG
Aviation	AVI
Avoirdupois	AVDP
Awning	AWN
Babbitt	BAB
Back-connected	BC
Back-feed	BF
Back pressure	BP
Back-water valve	BWV

Baffle	BAF
Baggage	BAG.
Balance	BAL
Ballast	BALL.
Ball Bearing	BB
Barbette	BARB.
Barracks	BKS
Barrel	BBL
Barrels per day	BPD
Barrels per hour	BPH
Base line	BL
Basement	BSMT
Base plate	BP
Batten	BATT
Battery (electrical)	BAT.
Battle	BAT.
Beacon	BCN
Beam	BM
Beams and stringers	B & S
Bearing	BRG
Bench mark	BM
Bend allowance	B.A.
Berthing	BERTH.
Between	BET.
Between centers	BC
Between perpendiculars	BP
Bevel	BEV
Beveled wood siding	BWS
Bill of lading	B/L
Bill of material	B/M
Billet steel	BT ST
Birmingham wire gage	BWG
Blackout door	BOD
Blackout window	BOW
Black powder	BP
Block	BLK
Blower	BLO
Blowoff	BO
Blue	BLU
Blueprint	B/P
Board	BD
Board foot	BF
Boiler	BLR
Boiler feed	BF
Boiler house	BH
Boiler pressure	BP
Booster	BSTR
Both faces	BF
Both sides	BS
Both ways	BW
Bottle	BOT
Bottom	BOT
Boundary	BDY
Bracket	BKT
Brass	BRS

Breaker	BKR
Brick	BRK
Bridge	BR
Brinell hardness	BH
Brinell hardness number	BHN
British standard	BR STD
British thermal unit	BTU
Broach	BRO
Bronze	BRZ
Brown and Sharpe (gage)	B & S
Browning aircraft machine (gun)	BAM
Browning automatic rifle	BAR.
Building	BLDG
Building line	BL
Bulkhead	BHD
Bull nose	BN
Buoyancy	B
Bureau	BU
Bushel	BU.
Bushing	BUSH.
Bus tie	BT
Button	BUT.
Buzzer	BUZ
By (used between dimensions)	X
Bypass	BP
Cabin	CAB.
Cable	CA
Cadmium	Cd
Calcium	Ca
Caliber	CAL
Calked joint	CAJ
Calking	CLKG
Camouflage	CAMOF
Canister	CSTR
Cantilever	CANTIL
Canvas	CANV
Capacitor	CAP
Carbon	C
Carbon steel	CS
Carburetor	CARB
Cargo	CAR.
Carrier	CARR
Case harden	CH
Casting	CSTG
Cast iron	CI
Cast-iron pipe	CIP
Cast steel	CST
Catalogue	CAT.
Cathode	k
Cathode ray	KR
Cathode ray tube	KRT
Cavity	CAV
Ceiling	CLG
Cement	CEM

Cement base .... CB
Cement floor .... CF
Cement mortar .... CEM MORT
Cement plaster .... CPL
Cement-plaster ceiling .... CPC
Center .... CTR
Center of buoyancy .... CB
Center of gravity .... CG
Center of pressure .... CP
Center line .... CL or L
Center tap .... CT
Center to center .... C TO C
Centigrade C
Centimeter .... CM
Centimeter gram second .... CGS
Centimeters per second .... CMPS
Centrifugal .... CENT.
Ceramic .... CER
Ceramic glazed structural facing units .... CGSFU
Ceramic glazed units .... CGU
Ceramic tile .... CT
Ceramic-tile floor .... CTF
Cesspool .... CP
Chain .... CH
Chamber .... CHAMB
Chamfer .... CHAM
Change .... CHG
Channel .... CHAN
Check .... CHK
Check valve CV
Chemical .... CHEM
Chlorine Cl
Chromium .... Cr
Circuit .... CKT
Circuit closing .... CKT CL
Circular .... CIR
Circular pitch .... CP
Circulate .... CIRC
Circulating water pump .... CWP
Circumference .... CIRC
Classification .... CLASS.
Clear .... CLR
Clearance CL
Clockwise .... CW
Closet .... CLO
Closure .... CLOS
Coaming .... COAM
Coated .... CTD
Coaxial .... COAX.
Cobalt .... Co
Coding .... COD.
Cofferdam .... COFF
Cold-rolled steel .... CRS
Color code CC
Column .... COL

Combat information center	CIC
Combination	COMB
Commercial	COML
Communication	COMM
Commutator	COMMUT
Companion	COMP
Company	CO
Compartment	COMPT
Compensator	COMP
Complement	COMP
Complete	COMPL
Completely knocked down	CKD
Complex operator	J
Composition	COMP
Composition floor	COMPF
Composition roof	COMPR
Compound	CMP
Compress	COMP
Compressed air	COMPA
Compressor	COMPR
Concentric	CONC
Concrete	CONC
Concrete block	CONCB
Concrete ceiling	CONCC
Concrete floor	CONCF
Condenser	COND
Conductivity	COND
Conduit	C
Confidential	CONF
Connector	CONN
Constant	CONST
Construction	CONSTR
Construction joint	CJ
Contact	CONT
Container	CNTR
Contaminated	CONTAM
Continue	CONT
Continuous wave	CW
Continuous window	CONT W
Contract	CONT
Contractor	CONTR
Contractor-furnished equipment	CFE
Control	CONT
Converter	CONV
Coolant	COOL.
Cooled	CLD
Copper	Cu
Cork base	CKB
Cork board	CKBD
Cork floor	CKF
Corner	COR
Corner bead	COR BD
Corrosion-resistant	CRE
Corrosion-resistant steel	CRES
Corrugate	CORR

Counter	CTR
Counterbalance	CBAL
Counterbore	CBORE
Counterclockwise	CCW
Countersink	CSINK
Countersink other side	CSINK-O
Counter weight	CTWT
Coupling	CPLG
Cowling	COWL
Crew (as spaces)	CR
Cross arm	X ARM
Cross connection	X CONN
Cross section	X SECT
Crystal	XTAL
Cubic	CU
Cubic centimeter	CC
Cubic feet per minute	CFM
Cubic feet per second	CFS
Culvert	CULV
Current	CUR.
Cutout	CO
Cutout valve	COV
Cycle	CY
Cycles per minute	CPM
Cycles per second	CPS
Cylinder	CYL
Damage control	DC
Damper	DMPR
Dated	DTD
Datum	DAT
Deadweight	DWT
Decalcomania	DECAL
Decibel	DB
Decimal	DEC
Deck	DK
Deck drain valve	DDV
Deck piercing	DP
Decontamination	DECONTN
Deflect	DEFL
Degree	DEG
De-icing	DI
Demolition	DML
Density	D
Department	DEPT
Depot installed	DEP INST
Depth charge	DC
Describe	DESCR
Design	DES
Designed water line	DWL
Detail	DET
Detector	DET
Develop	DEV
Developed horsepower	DHP
Diagonal	DIAG

Diagram	DIAG
Diameter	DIA
Diaphragm	DIAPH
Diesel oil	DO.
Differential	DIFF
Diffusing	DIFFUS
Dilution	DIL
Dimension	DIM
Diode	D
Direct current	DC
Direct-current volts	VDC
Direction	DIR
Direction finder	DF
Disassembly	DISASSY
Discharge	DISCHG
Disconnect	DISC
Dispensary	DISP
Distant	DIST
Distill	DSTL
Distilled water	DW
Distributor	DISTR
Ditto	DO
Division	DIV
Door	DR
Door stop	D ST
Double	DBL
Double acting	DBL ACT.
Double-acting door	DAD
Double end	DE
Double pole both connected	DPBC
Double pole, double throw	DPDT
Double pole front connected	DPFC
Double pole, single throw	DPST
Double throw	DT
Double weight	DW
Doubler	DBLR
Dovetail	DVTL
Dowel	DWL
Down	DN
Downspout	DS
Dozen	DOZ
Dram	DR
Drawing	DWG
Drawn	DRWN
Dressed and matched	D & M
Drill	DR
Drive	DR
Drydock	DD
Dry pipe valve	DPV
Duplicate	DUP
Dynamic	DYN
Dynamotor	DYN
Each	EA
Each face	EF
Each layer	EL

Eccentric	ECCEN
Eductor	EDUC
Effective	EFF
Efficiency	EFE
Ejector	EJECT
Elastic limit	EL
Elbow	ELL
Electric	ELEC
Electric horsepower	EHP
Electrolytic	ELECT.
Electromotive force	EMF
Elevate	ELEV
Elevation	EL
Eliminate	ELIM
Elongation	ELONG
Emergency	EMER
Empennage	EMP
Enclosure	ENCL
End to end	E TO E
Engine	ENG
Engineering	ENGR
Entrance	ENT
Envelope	ENV
Equal	EQ
Equal section	ES
Equation	EQ
Equipment	EQUIP.
Equipment and spare parts	E & SP
Equivalent	EQUIV
Escape	ESC
Estimate	EST
Et cetera	ETC
Evaporate	EVAP
Excavate	EXC
Exciter	EXC
Exclusive	EXCL
Exercise	EXER
Exhaust	EXH
Exhaust vent	EXH V
Exhibit	EXH
Existing	EXIST.
Expansion	EXP
Experimental	EXP
Explosion-proof	EP
Expulsion	EXPUL
Extension	EXT
Exterior	EXT
External	EXT
Extinguish	EXT
Extra	EXT
Extra heavy	X HVY
Extra strong	X STR
Extreme high water	EHW
Extreme low water	ELW
Extrude	EXTR

Fabricate	FAB
Face to face	F TO F
Facing	FCG
Fahrenheit	F
Fairing	FAIR.
Farad	F
Far side	FS
Feeder	FDR
Feed water	FW
Feet board measure	FBM
Feet per minute	FPM
Feet per second	FPS
Field	FLD
Figure	FIG
Filament	GIL
Fillet	FIL
Filling	FILL.
Filter	FIL
Finish	FIN
Finish all over	FAO
Finish one side	F1S
Finish two sides	F2S
Fire	F
Fire and bilge	F & B
Fire and flushing	F & F
Fire clay	FC
Fire control	FC
Fire door	FDR
Fire hose	FH
Fire-hydrant	FHY
Fire main	FM
Fireproof	FPRF
Fitting	FTG
Fixed	FXD
Fixture	FIX
Flameproof	FP
Flange	FLG
Flashing	FLG
Flat-tile roof	FTR
Flexible	FLEX.
Float	FLT
Flotation	FLOT
Floor	FL
Floor drain	FD
Flooring	FLG
Fluid	FL
Fluorescent	FLUOR
Flush valve	FV
Foot	FT
Footing	FTG
Foot-pound	FT LB
For example	EG
Force	F
Forecastle	FCSLE
Forged steel	FST

Forging	FORG
Fork	FK
Forward	FWD
Foundation	FDN
Foundry	FDRY
Four-conductor	4/c
Four-pole	4P
Four-way	4-WAY
Fragmentation	FRAG
Frame	FR
Framework	FRWK
Freeboard	FREEBD
Frequency	FREQ
Frequency modulation	FM
Fresh water	FW
Friction	FRICT
From below	FR BEL
Front	FR
Fuel	F
Fuel oil	FO
Furnish	FURN
Fuselage	FUS
Gage or gauge	GA
Gallon	GAL
Gallons per day	GPD
Gallons per hour	GPH
Gallons per minute	GPM
Gallons per second	GPS
Galvanized	GALV
Galvanized iron	GI
Galvanometer	GALV
Garboard	GARBD
Gas	G
Gas ejection	GE
Gasket	GSKT
Gasoline	GAS
Gate valve	GV
General	GEN
Generator	GEN
Girder	G
Glass	GL
Glass block	GLB
Glazed	GL
Glazed facing units	GFU
Glazed wallboard	GLWB
Glazed wall tile	GWT
Glazed wall tile base	GWTB
Globe stop valve	GSV
Globe valve	GLV
Gold (aurum)	Au
Government furnished equipment	GFE
Governor	GOV
Granite	GRAN
Graphite	GPH

Grating	GRTG
Gravel	GRAV
Grease trap	GT
Grid	g
Grind	GRD
Grommet	GROM
Gross	GRO
Gross ton	GT
Ground	GND
Group	GP
Guard	GD
Gunnery	GUN.
Gypsum	GYP
Gypsum-plaster ceiling	GPC
Gypsum-plaster wall	GPW
Gyroscope	GYRO
Half gross	½GRO
Half-hard	½H
Half-round	½RD
Hand control	HC
Hand generator	HG
Handhold	HH
Handling	HAND.
Hand rail	HDR
Hand wheel	HD WHL
Hanger	HGR
Hard	H
Hard chromium	HD CR
Hard-drawn	HD
Harden	HDN
Hardware	HDW
Hardwood	HDWD
Hatch	H
Head	HD
Heat	HT
Heater (electronic tubes)	h
Heat treat	HT TR
Heavy	HVY
Height	HGT
Helium	He
Hexagon	HEX
High	HI
High frequency	HF
High point	HPT
High potential	H POT.
High pressure	HP
High-pressure steam	HPS
High speed	HS
High-speed steel	HSS
High tension	HT
High voltage	HV
High-water line	HWL
Highway	HWY
Hollow	HOL

Hollow metal	HM
Hollow metal door and frame	HMDF
Hollow tile	HT
Horizontal	HOR
Horizontal shear	HS
Horsepower	HP
Hose rack	HR
Hospital	HOSP
Hot-rolled steel	HRS
Hot water	HW
Hot-water circulating	HWC
Hour	HR
Housing	HSG
Hundredweight	CWT
Hydraulic	HYD
Hydroelectric	HYDROELEC
Hydrogen	H
Identification	IDENT
Ignition	IGN
Illuminate	ILLUM
Illustration	ILLUS
Impact	IMP
Impregnate	IMPG
Inboard	INBD
Incendiary	INC
Inch	IN.
Inch-pound	IN. LB
Inches per second	IPS
Incinerator	INCIN
Inclined	INCL
Inclosure	INCL
Include	INCL
Incoming	INC
Independent	INDEP
Indicate	IND
Inductance-capacitance	LC
Inductance coil	L
Induction	IND
Industrial	IND
Inflammable	INFL
Information	INFO
Injection	INJ
Inside diameter	ID
Inside layer	IL
Inspection	INSP
Installation	INSTL
Instantaneous	INST
Institute of Aeronautical Sciences	IAS
Institute of Radio Engineers	IRE
International Pipe Standard	IPS
International Standard Thread (Metric)	INT-STD-THD
Instruction	INST
Instrument	INST
Insulate	INS

Intercept	INTCPT
Interchangeable	INTCHG
Intercommunication	INTERCOM
Interior	INT
Interior communication	IC
Interlock	INTLK
Intermediate	INTER
Intermediate frequency	IF.
Intermittent	INTMT
Internal	INT
Interrupt	INTER
Interrupted continuous wave	ICW
Intersection	INT
Inverse	INV
Invert	INV
Iron (Abbreviate only in conjunction with other materials.)	I
Iron (Ferrum)	Fe
Iron pipe size	IPS
Irregular	IRREG
Island	IS.
Isolation ward	ISOWD
Issue	ISS
Jack	J
Job order	JO
Joggle	JOG.
Joint	JT
Joint Army-Navy	JAN
Joist	J
Joists and planks	J & P
Joule	J
Junction	JCT
Junction box	JB
Keel	K
Keyseat	KST
Keyway	KWY
Kiln-dried	KD
Kilo (10^3)	K
Kilocycle	KC
Kilogram	KG
Kilograms per second	KGPS
Kilohm	K
Kiloliter	KL
Kilo-mega (10^9)	KM
Kilo-megacycles (10^9)	KMC
Kilometer	KM
Kilometers per second	KMPS
Kilovolt	KV
Kilovolt-ampere	KVA
Kilovolt-ampere hour	KVAH
Kilowatt	KW
Kilowatt hour	KWH
Knee brace	KB
Knife switch	KN SW

Knock down	KD
Knockout	KO
Knot	KN
Laboratory	LAB
Lacquer	LAQ
Ladder	LAD.
Laminate	LAM
Landing	LDG
Landing gear	LG
Landmark	LD MK
Lateral	LAT
Latitude	LAT
Laundry	LAU
Lavatory	LAV
Lead (plumbum)	Pb
Leading edge	LE
Leather	LTHR
Left	L
Left hand	LH
Length	LG
Length over-all	LOA
Letter	LTR
Light	LT
Lightening	LTG
Lighting	LTG
Lightning arrester	LA
Lightproof shade	LPS
Limit	LIM
Linear	LIN
Linoleum	LINOL
Linoleum floor	LF
Lintel	LNTL
Liquid	LIQ
Liter	L
Live load	LL
Load water line	LWL
Locate	LOC
Locked	LKD
Locker	LKR
Long	LG
Longitudinal	LONG.
Longitudinal expansion joint	LEJ
Lookout	LKT
Loudspeaker	LS
Low-water line	LWL
Lower	LWR
Lower deck	LDK
Low frequency	LF
Low point	LP
Low pressure	LP
Low speed	LS
Low tension	LT
Low voltage	LV
Lubricate	LUB

Lubricating oil	LO
Lumber	LBR
Machine	MACH
Machine gun	MG
Machine screw	MS
Machine steel	MS
Magazine	MAG
Magazine flooding and sprinkling	MF & S
Magnaflux	M
Magnesium	Mg
Magnet	MAG
Magneto	MAG
Magnetomotive force	MMF
Mail box	MB
Main	MN
Main feed	MF
Main landing gear	MLG
Maintenance	MAINT
Malleable	MALL.
Malleable iron	MI
Maneuvering	MANUV
Manganese	Mn
Manhole	MH
Manifold	MAN.
Manual volume control	MVC
Manufacture	MFR
Manufacturing	MFG
Marble	MR
Marble floor	MRF
Margin	MARG
Mark	MK
Masking	MASK.
Masonry	MSNRY
Masonry opening	MO
Master	MA
Mastic	MSTC
Mastic floor	MF
Mastic joint	MJ
Material	MATL
Maximum	MAX
Maximum working pressure	MWP
Measure	MEAS
Mechanical	MECH
Medium	MED
Medium high frequency	MHF
Medium pressure	MP
Megacycle	MC
Megawatt-	MW
Megawatt-hour	MWH
Megohm	MEG
Melting point	MP
Membrane	MEMB
Membrane waterproofing	MWP
Memorandum	MEMO

Mercury (hydrargyrum)	Hg
Meridian	MER
Metal	MET.
Metal base	METB
Metal corner bead	MCB
Metal-covered door	MCD
Metal door	METD
Metal flashing	METF
Metal grille	METG
Metal mold	METM
Metal partition	METP
Metal strip	METS
Meter	M
Mezzanine	MEZZ
Micro (10^{-6})	U or *u*
Micro micro (10^{-12})	UU or *uu*
Microampere	UA or *u*A
Microampere (peak)	Ua or *ua*
Microfarad	UF or *u*F
Microhenry	UH or *u*H
Microhm	UMHOS or *u*MHOS
Micromicro farad	UUF or *uu*F
Micromicron	UU or *uu*
Micron (.001 millimeter)	U or *u*
Microminute	UMIN or *u*MIN
Microphone	MIKE
Microsecond	USEC or *u*SEC
Microvolt	UV or *u*V
Microvolt per meter	UV/M or *u*V/M
Microwatt	UW or *u*W
Middle	MID.
Mile	MI
Miles per gallon	MPG
Miles per hour	MPH
Miles per hour per second	MPHPS
Military	MIL.
Milli (10^{-3})	M
Milliampere	MA
Millifarad	MF
Milligram	MG
Millihenry	MH
Millilambert	ML
Milliliter	ML
Millimeter	MM
Minimum	MIN
Minute	MIN
Miscellaneous	MISC.
Mixture	MIX.
Model	M
Modification	MOD
Modulated continuous wave	MCW
Modulator	MOD
Molded	MLD
Molding	MLDG
Mold line	ML

Molybdenum	Mo
Momentary contact	MC
Monitor	MON
Month	MO
Motor	MOT
Motorboat	MB
Motor generator	MG
Mounting	MTG
Multiple	MULT
Multipole	MP
Nacelle	NAC
Namely	VIZ
National	NATL.
National Aircraft Standards	NAS
National Aircraft Standards Committee	NASC
National Board of Fire Underwriters	NBFU
National Electrical Code	NEC
National Electrical Code Standards	NECS
National Fire Protection Association	NFPA
National Lumber Manufacturers Association	NLMA
National Safety Council	NSC
Natural	NAT
Navigation	NAV
Near face	NF
Near side	NS
Negative	NEG.
Neon	Ne
Network	NET.
Neutralizing	NEUT
New British Standard (imperial wire gage)	NBS
Nickel	Ni
Nickel steel	NS
Nipple	NIP.
Nitrogen	N
Noncorrosive metal	NCM
Nontight	NT
Nonwatertight (switches)	NWT
Normal	NOR
Not in contract	NIC
Not to scale	NTS
Nozzle	NOZ
Number	NO
Observation	OBS
Observation window	OBW
Obsolete	OBS
Octane	OCT
Office	OFF
Oil circuit breaker	OCB
On center	OC
Open-close-open	OCO
Opening	OPEN.
Operate	OPR
Opposite	OPP

Optical	OPT
Ordnance	ORD
Orifice	ORF
Original	ORIG
Oscillator	OSC
Oscilloscope	SCOPE.
Ounce	OZ
Outboard	OUTBD
Outlet	OUT.
Over	OV
Overflow	OVFL
Overload	OVLD
Oversize	OS
Oxygen	O
Package	PKG
Painted	PTD
Painted base	PB
Painted metal	PMET
Paints and oil	P & O
Pair	PR
Panel	PNL
Parallel	PAR.
Partition	PARTN
Passage	PASS.
Patent	PAT
Pattern	PATT
Penny (nail size)	d
Pennyweight	DWT
Pentode	PENT.
Per centum	PCT
Perforate	PERF
Permanent	PERM
Perpendicular	PERP
Phase	PH
Pick-up	PU
Piece	PC
Pint	PT
Pitch	P
Pitch circle	PC
Pitch diameter	PD
Pitch mark	PMK
Plank	PLK
Plan position indicator	PPI
Plaster	PLAS
Plastic	PLSTC
Plate (electron tubes)	P
Plate glass	PLGL
Platform	PLATF
Platinum	Pt
Plumbing	PLMB
Plywood	PLYWD
Point	PT
Polyphase	PYPH
Porcelain	PORC

Port	P
Port and starboard	P & S
Position	POSN
Positive	POS
Potential	POT
Pound	LB
Powder	PWD
Power	PWR
Practice	PRAC
Precast	PRCST
Prefabricated	PREFAB
Preferred	PRFRD
Preliminary	PRELIM
Premolded	PRMLD
Prepare	PREP
Pressure	PRESS.
Pressure-proof	PP
Pressure reducing valve	PRV
Primary	PRI
Private automatic exchange	PAX
Private branch exchange	PBX
Production	PROD.
Projection	PROJ
Proof	PRF
Propeller	PROP
Proposed	PROP
Protective	PROT
Provision	PROV
Publication	PUB
Public address	PA
Pull button	PLB
Pull switch	PS
Pulsating current	PC
Pulverizer	PULV
Push button	PB
Push-pull	P-P
Pyrotechnic	PYRO
Quality	QUAL
Quantity	QTY
Quart	QT
Quarter	QTR
Quarter-hard	¼H
Quarter-phase	¼PH
Quarter-round	¼RD
Quartz	QTZ
Quick-acting	QA
Quick-opening device	QOD
Radar	RDR
Radio	RAD
Radio direction finding	RDF
Radio frequency	RF
Radius	R or RAD
Railing	RLG

Railroad	RR
Railway	RY
Raised	RA
Ready service	RS
Rear view	RV
Reassemble	REASM
Received	RECD
Receiver	REC
Receptacle	RECP
Reception	RECPT
Reciprocating	RECIP
Recognition	RECOG
Recommend	RECM
Reconnaissance	RECONN
Recorder	REC
Rectangle	RECT
Rectifier	RECT
Reducer	RED.
Reference	REF
Reference line	REF L
Reflector	REFL
Refrigerate	REFR
Regenerative	REGEN
Register	REG
Regular	REG
Regulator	REG
Reinforce	REINF
Reinforced concrete	RC
Reinforcing steel	RST
Relay	REL
Release	REL
Relief	REL
Relief valve	RV
Remote control system	RCS
Removable	REM
Repair	REP
Replace	REPL
Request	REQ
Required	REQD
Requisition	REQN
Reserve	RES
Resistance	RES
Resistance-capacitance	RC
Retainer	RET
Retractable	RETR
Return	RET
Reverse	REV
Revise	REV
Revolution	REV
Revolutions per minute	RPM
Revolutions per second	RPS
Rheostat	RHEO
Right	R
Right of way	R/W
Right hand	RH

Ring	RG
Riser	R
Rivet	RIV
Rocker	RKR
Rockwell hardness	RH
Roofing	RFG
Room	RM
Rotary	ROT.
Rough	RGH
Round	RD
Rubber	RBR
Rubber insulation	RI
Rubber-tile floor	RTF
Rudder	RUD
Safety	SAF
Salt water	SW
Salvage	SALV
Sand blast	SD BL
Sanitary	SAN
Schedule	SCH
Schematic	SCHEM
Scleroscope hardness	SH
Screen	SCRN
Screen door	SCD
Scupper	SCUP
Scuttle	S
Second	SEC
Section	SECT.
Selenium	Se
Self-closing	SELF-CL
Selsyn	SELS
Semifixed	SFXD
Separate	SEP
Serial	SER
Series	SER
Service	SERV
Service fuel oil	SFO
Set screw	SS
Settling	SETT
Sewage	SEW.
Shaft alley	SA
Shaft horsepower	SHP
Shear plate	SP
Sheating	SHTHG
Sheet	SHT
Shell	SH
Shield	SHLD
Shipment	SHPT
Shock absorber	SH ABS
Shore connection	SH CON
Short wave	SW
Shower	SH
Shower drain	SD
Shrapnel	SHRAP

Shut-off valve	SOV
Siding	SDG
Signal	SIG
Silicon	Si
Silver	SIL
Silver (argentum)	Ag
Silver solder	SILS
Similar	SIM
Single	SGL
Single conductor	1/C
Single end	SE
Single feeder	SF
Single phase	1PH
Single pole	SP
Single throw	ST
Sink	SK
Sketch	SK
Skylight	SLT
Sliding door	SLD
Slotted	SLTD
Slow release	SR
Small	SM
Smoke	SMK
Smooth contour	SC
Society for Advancement of Management	SAM
Society of American Military Engineers	SAME
Society of Automotive Engineers	SAE
Society of Naval Architects and Marine Engineers	SNA & ME
Socket	SO.
Socket head	SCH
Sodium (natrium)	Na
Solenoid	SOL
Sound	SD
Space	SPC
Spacer	SPCR
Spare	SP
Spark	SP
Speaker	SPKR
Special	SPL
Specification	SPEC
Specific gravity	SP GR
Specific heat	SP HT
Specimen	SPEC
Spherical	SPHER
Split ring	SR
Spring	SPG
Sprinkler	SPR
Square	SQ
Stairway	STWY
Stanchion	STAN
Standard	STD
Starboard	STBD
Station	STA
Stationary	STAT

Steam	STM
Stiffener	STIFF.
Stone	STN
Storage	ST
Store	ST
Stowage	STOW.
Straight shank	SS
Strainer	STR
Strake	STK
Strength	STR
Stringer	STGR
Structural	STRUCT
Submerged	SUB
Subsequent	SUBQ
Substitute	SUB
Substructure	SUBSTR
Suction	SUCT
Sulfur	S
Supercharge	SUPCHG
Superseded	SUPSD
Superstructure	SUPERSTR
Supply	SUP.
Support	SUP.
Surface	SURF.
Surfaced or dressed one side	S1S
Surfaced or dressed two sides	S2S
Surfaced or dressed four sides	S4S
Surfaced or dressed one side and one edge	S1S1E
Survey	SURV
Suspend	SUSP
Suspended plaster ceiling	SPC
Swash (used with other words or abbreviations)	SW
Swing	SWG
Switch	SW
Switchboard	SWBD
Symbol	SYM
Symmetrical	SYM
Synchronous	SYNC
Synthetic	SYN
System	SYS
Tarpaulin	TARP
T-bar (structural shape)	T
Technical	TECH
Technical manual	TM
Tee	T
Telegraph	TG
Telephone	TEL
Telescope	TEL
Teletypewriter	TT
Teletypewriter exchange	TWX
Temperature	TEMP
Tempered	TEMP
Template	TEMP

Tensile strength	TS
Tension	TENS.
Tentative	TENT.
Terminal	TERM
Terra cotta	TC
Theoretical	THEOR
Thermocouple	THERMOC
Thermometer	THERM
Thermostat	THERMO
Thick	THK
Thorium	Th
Thousand pounds (structural)	KIP
Thread	THD
Three-conductor	3/C
Three-phase	3PH
Three-pole	3P
Three-way	3-WAY
Throttle	THROT
Through	THRU
Thrust line	TL
Tile base	TB
Tile drain	TD
Tile floor	TF
Timber	TMBR
Time	T
Time delay	TD
Tin (stannum)	Sn
Titanium	Ti
Toggle	TOG.
Tolerance	TOL
Ton	T
Tongue and groove	T & G
Tool steel	TST
Top and bottom	T & B
Total load	TL
Trailing edge	TE
Training	TNG
Transceiver	XCVR
Transfer	TRANS
Transformer	TRANSF
Transmission	XMSN
Transmit-receiver	TR
Transmitter	XMTR
Transmitting	XMTG
Transportation	TRANS
Transverse	TRANSV
Treatment	TREAT.
Triode	TRI
Trunk	TR
Trunnion	TRUN
Truss	T
Tubing	TU
Tungsten (wolfranium)	W
Turbine	TURB
Turbine generator (driver)	TURBO GEN

Turbo-jet propulsion	TJP
Turnbuckle	TRNBKL
Turnout	TO.
Turret	TUR
Twisted	TW
Two-conductor	2/C
Two-phase	2PH
Two-way	2-WAY
Typical	TYP
Ultimate	ULT
Ultra-high frequency	UHF
Under	UND
Undersize	US.
Underwater	UNDW
Underwriters' Laboratories, Inc.	ULI
Unfinished	UNFIN
United States gage	USG
United States standard	USS
Universal	UNIV
Upper	UP
Uranium	U
Urinal	UR
Used with	U/W
Utility	UT
Vacuum	VAC
Vacuum tube	VT
Valve	V
Valve box	VB
Variable	VAR
Ventilate	VENT.
Vent pipe	VP
Vent stack	VS
Vertical	VERT
Very-high frequency	VHF
Video frequency	VF
Vitreous	VIT
Voice tube	VT
Void	VD
Volt ohm milliammeter	VOM
Volt	V or E
Volt ampere	VA
Voltammeter	VAM
Voltmeter	VM
Volume	VOL
Wainscot	WA
Wall board	WLB
Ward room	WR
Washroom	WR W
Waste pipe	WP
Water	W
Water closet	WC

Water cooler	WCL
Water cooled	WCLD
Water line	WL
Waterproofing	WPG
Watertight	WT
Watt	W
Watt-hour	WH
Wattmeter	WM
Weatherproof	WP
Weather stripping	WS
Weather-tight	WEA-T
Weight	WT
Wire (Abbreviate only in conjunction with other materials.)	W
With (Abbreviate only in conjunction with other abbreviations.)	W/
Withdrawn	W/D
Without	W/O
Wood door	WD
Wood door and frame	WDF
Wood panel	WDP
Wrought iron	WI
Yard	YD
Yield point (psi)	YP
Yield strength (psi)	YS
Zee	Z
Zinc	Zn
Zirconium	Zr

APPENDIX III

FRACTIONS AND DECIMAL EQUIVALENTS

8 ths	16 ths	32 nds	64 ths	Decimal	8 ths	16 ths	32 nds	64 ths	Decimal
			1	0. 015 625				33	0. 515 625
		1	2	. 031 25			17	34	. 531 25
			3	. 046 875				35	. 546 875
	1	2	4	. 062 5		9	18	36	. 562 5
			5	. 078 125				37	. 578 125
		3	6	. 093 75			19	38	. 593 75
			7	. 109 375				39	. 609 375
1	2	4	8	. 125	5	10	20	40	. 625
			9	. 140 625				41	. 640 625
		5	10	. 156 25			21	42	. 656 25
			11	. 171 875				43	. 671 875
	3	6	12	. 187 5		11	22	44	. 687 5
			13	. 203 125				45	. 703 125
		7	14	. 218 75			23	46	. 718 75
			15	. 234 375				47	. 734 375
2	4	8	16	. 25	6	12	24	48	. 75
			17	. 265 625				49	. 765 625
		9	18	. 281 25			25	50	. 781 25
			19	. 296 875				51	. 796 875
	5	10	20	. 312 5		13	26	52	812 5
			21	. 328 125				53	. 828 125
		11	22	. 343 75			27	54	. 843 75
			23	. 359 375				55	. 859 375
3	6	12	24	. 375	7	14	28	56	. 875
			25	. 390 625				57	. 890 625
		13	26	. 406 25			29	58	. 906 25
			27	. 421 875				59	. 921 875
	7	14	28	. 437 5		15	30	60	. 937 5
			29	. 453 125				61	. 953 125
		15	30	. 468 75			31	62	. 968 75
			31	. 484 375				63	. 984 375
4	8	16	32	. 50					

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